DOCUMENT RESUME

ED 384 520 SE 056 507

AUTHOR	Jensen, Rosalie S.; And Others
TITLE	Integrated Mathematics and Science Courses for Preservice Teachers, K-8 or 4-8.
SPONS AGENCY	Eisenhower Program for Mathematics and Science Education (ED), Washington, DC.
PUB DATE	Sep 94
CONTRACT	E4-MSC8
NOTE	182p.
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052)
EDRS PRICE	MF01/PC08 Plus Postage.
DESCRIPTORS	Course Descriptions; Elementary Education; Higher Education; *Integrated Activities; *Integrated Curriculum; Interdisciplinary Approach; Mathematics Education; *Preservice Teacher Education; Science Activities; Science Education; Worksheets
IDENTIFIERS	Mathematics Activities

ABSTRACT

The National Council of Teachers of Mathematics, the National Science Teachers Association, and the American Association for the Advancement of Science present compelling arguments for teachers to make connections with other disciplines. This document describes integrated mathematics and science courses developed at North Georgia College. Appendix A contains the syllabi for Mathematics 310 and Physics 460, which are to be taken together in a block. The syllabi discuss: prerequisites, philosophical basis, course objectives, course procedures, tests, assignments, projects, evaluation, and course calendar. Appendix B and C present the outline of topics covered, references, and activities for the courses. Appendix D includes hand-out pages describing problem-solving strategies currently developed in mathematics classrooms, process skills developed in science classrooms, and a mathematics skills sequence chart. Appendix E gives an overview of how the field experience is arranged and evaluated and provides sample forms. Students are required to create a resource unit and Appendix F contains a description, an evaluation form, and a sample activity. Appendix G contains sample tests. Appendix H includes selected comments from students in response to a survey completed at the end of the course. (MKR)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 384 520

INTEGRATED MATHEMATICS AND SCIENCE COURSES

FOR PRESERVICE TEACHERS, K-8 OR 4-8

Prepared by

Rosalie S. Jensen
Project Director
Professor and Head of
Department of Mathematics and Computer Science
North Georgia College
Dahlonega, GA 30597

Susan B. Gannaway
Associate Director
Professor and Director of
Center for Science, Mathematics,
and Environmental Education
North Georgia College
Dahlonega, GA 30597

Margaret P. Sloan
Project Coordinator
Graduate Assistant
Department of Mathematics and Computer Science
North Georgia College
Dahlonega, GA 30597

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

Minor changes have been made to improve reproduction quality.

Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

ROSALIE JENSEN
Susan P. Gannaway

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Funded by Dwight D. Eisenhower Mathematics and Science Education Improvement Program, High Education Grant
Georgia Plan Project Number E4-MSC8

BEST COPY AVAILABLE

An Integrated Mathematics and Science Course for Pre-service Teachers

K-8 or 4-8

Philosophical Base

The notion of integrating mathematics and science instruction is not new; however, the concept has gained momentum through recent efforts of professional groups and agencies. According to the authors of *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (National Research Council, 1989, p.2):

> Mathematics and scientific literacy form the basis of technological expertise in the workplace. In tomorrow's world, the best opportunities for jobs and advancement will go to those prepared to cope confidently and competently with mathematical, scientific, and technological issues.

The National Council of Teachers of Mathematics (NCTM), the National Science Teachers Association (NSTA), and the American Association for the Advancement of Science (AAAS) present compelling arguments for teachers to make connections with other disciplines.

According to the authors of *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989, p. 85), "...the integration of mathematics into contexts that give its symbols and processes practical meaning is an overreaching goal of all the standards." Along the same lines, the authors of the *NSTA Standards for Science Teacher Preparation* (NSTA, 1992) recommend that the preparation of pre-service science teachers at all levels foster "a holistic understanding of science, minimizing the rigid boundaries among the sciences and emphasiziang the interconnections with other subject areas." Concerning mathematics, the authors of *Science for All Americans* (AAAS, 1989, p. 101) state:

> Mathematics is essentially a process of thinking that involves building and applying abstract, logically connected networks of ideas. These ideas arise from the need to solve problems in science, technology, and everyday life - problems ranging from how to model certain aspects of a complex scientific problem to how to balance a checkbook.

A case for integrating mathematics and science is presented in the article "Integrating Elementary/Middle School Science and Mathematics" (McBride, 1991, pp. 286-87). The following reasons for integration are provided:

1. Science and mathematics are closely related systems of thought and are naturally correlated in the physical world.
2. Science can provide students with concrete examples of abstract mathematical ideas that can improve learning of mathematics concepts.
3. Mathematics can enable students to achieve a deeper understanding of science concepts by providing ways to quantify and explain science relationships.
4. Science activities which illustrate mathematics concepts can provide relevancy and motivation for learning mathematics.

The Georgia Initiative in Mathematics and Science (Project GIMS) has goals for pre-service education teachers which support the integration of mathematics and science in the curriculum of institutions of higher education. The following goals are included in the framework of the project:

1. Develop teachers with strong content and pedagogical foundations that enable them to make real world applications and connections.
2. Develop and implement curriculum that is application-based, interdisciplinary, and requires active student participation.
3. Design innovative assessment techniques that reflect curriculum goals and instructional strategies appropriate to math and science.

During the 1991-92 academic year Dr. Susan Gannaway, Professor of Education, and Dr. Rosalie Jensen, Professor of Mathematics and Computer Science, began a team-teaching project that evolved into the integrated mathematics and science courses that are described in this document. In addition to satisfying state and national goals for instruction in content fields, they designed the two courses to be consistent with the general guidelines for curriculum outlined in the brochure "North Georgia College Teacher Education Program." A copy of the publication is included in the front of this document. The publication describes the Model for Teacher Education: A Metacognitive Perspective, along with objectives and outcomes, the curriculum sequence, and the knowledge base of programs.

The remainder of this publication is devoted to explaining the structure of the ten quarter hour block in mathematics and science and providing examples of materials for instruction and assessment developed for the two courses.

The Curriculum Sequence

Mathematics 310 and Physics 460 are included in Phase II, the Content Phase, of the curriculum sequence for prospective teachers of grades K-4, grades 4-8, and Special Education. (See "North Georgia College Teacher Education Program.") The purpose of this phase is to help education majors learn worthwhile academic content as well as ways to conceptualize and represent this content later to their students. By blocking the two courses together, the instructors can build a bridge between Phase II and Phase III, which includes courses in general methods and materials, curriculum, and classroom management. While participating in a one week teaching experience in mathematics and science, students gain understanding on a practical level of theories and principles that will be formalized in courses completed in Phase III and applied during the Student Teaching Phase.

Unique Features

Compatible Syllabi

Syllabi for Mathematics 310 and Physics 460 are contained in **Appendix A**. A comparison of the objectives of the two syllabi reveals that standard subject matter for the field is included in each course; however, common objectives and assignments related to application of the content to classroom teaching are also included for each course. By pooling time, resources, and personal expertise, the two instructors are able to present an appropriate body of content without needlessly duplicating practice on concepts and skills.

Evolving Calendar

A copy of a typical calendar for one quarter is included in **Appendix A**. The two instructors create the calendar together, insuring that as much time as possible is allowed between dates on which assignments

and tests for the two courses are scheduled.

The most important single event of the quarter is the week-long field experience in a local elementary school; therefore, the schedule reflects the need to prepare the students for the experience while continuing to develop content at a reasonable rate throughout the quarter.

Scheduling

During most quarters the college schedule lists Physics 460 on Monday, Wednesday, and Friday from 1:00 p.m. to 3:00 p.m. and Mathematics 310 on Tuesday, Thursday, and Friday from 1:00 p.m. to 3:00 p.m. A few students may be enrolled in one course but not the other because of individual circumstances (e.g., transferred one course or failed one course in a previous quarter); therefore, scheduling both courses on Friday indicates to students that they must reserve Friday afternoon for common class meetings and other activities.

Sequencing Content

Although the outline in **Appendix B** for Mathematics 310 is numbered according to chapters and sections in the course textbook, some rearragements of content are necessary to provide students with the mathematics content needed to understand the concepts and skills presented in Physics 460 early in the quarter. For example, section 3.1, "Numeration Systems", is developed first so that students can be introduced to properties of our numeration systems necessary for understanding conversions within the metric measurement system, scientific notation, and features of a four function calculator. Although problem solving strategies from the section 1.1, "Introduction to Problem Solving," and 1.2, "Patterns and Problem Solving," are developed next, many of the problems in the textbook are reserved for sessions scheduled later to coordinate with the study of whole numbers, integers, rational numbers, decimals, number theory, and selected topics from geometry of the plane. The sequencing of content for the entire quarter is included on the calendar in **Appendix A**.

The science course begins with a detailed introduction to measurement, including systems of measurement and conversions. Calculators are introduced at the beginning of the math course and used as area, volume, and density concepts are developed. Place value concepts are used in teaching rounding and estimation, especially as it applies to calculator usage. In the Georgia elementary school curriculum, measurement skills are detailed in mathematics but used in science; therefore, this is an ideal first point of integration.

Activities that emphasize measurement skills are generally applied in the field experience. Because these activities often involve formal and informal geometry and require skills related to multiplication, division, fractions, and decimals, the field experience provides an opportunity to discuss appropriate skill sequencing. **Appendix D** contains a chart showing how mathematical skills needed in science are sequenced.

The science content then moves to a consideration of machines, forces, and energy. Geoboards are used to introduce the concepts of vectors and resultant forces. Ratio and fractions are developed during the section on simple machines and extended immediately in the mathematics course.

The final science unit focuses on magnetism and electricity. Mathematics applications developed include observing quantitative relationships such as how the strength of an electromagnet varies with the number of turns or how the attractive force is related to the distance from a magnet. In this

unit, as in the previous ones, attention is given to observation and graphing of direct and inverse relationships as well as proportional reasoning.

Both courses share a common instructional strategy. Manipulative aids are used in small group settings. As content is introduced, Georgia QCC objectives are used to demonstate to students where the content fits. Both instructors routinely indicate whether knowledge being presented is background or commonly used in instruction. Strategies for working with groups, using manipulatives, finding curriculum materials, and integrating science and mathematics are both modelled and explained as the quarter progresses.

Problem Solving and Process Skills

Appendix D contains hand-out pages describing problem solving strategies currently developed in mathematics classrooms, process skills developed in science classrooms, and a mathematics skills sequence chart. Because of the interrelated nature of these components, they are presented during the first Friday session of the quarter so that students will have an opportunity to apply the strategies and processes and have access to the skills sequence throughout the quarter.

Both the problem solving strategies and the process skills selected are ones that appear in mathematics and science Quality Core Curriculum (QCC) Objectives for grades K-8. This early introduction of the QCC Objectives is viewed as a way of showing our students that they are studying concepts and skills that they will use in K-8 classrooms. Students also discover that scientists and mathematicians sometimes use different vocabularies in describing the same or similar activities.

Common Field Experience

In addition to offering the opportunity of interrelating the content and showing similarities in processes of the two disciplines, creating a block of the two courses that is scheduled for two hours each day makes possible the scheduling of a field experience in a local school.

The purpose of **Appendix E** is to give an overview of how the field experience is arranged and evaluated. Because of the relative complexity of planning and implementing this activity, explanations for some details are provided here.

One instructor is responsible for making arrangements with a local school for the week-long field-based experience. In our case, the Lumpkin County School System has only two elementary schools; therefore, we alternate field sites each quarter. The instructor in charge follows these steps:

1. Make arrangements with school personnel for our students to work with children in grades 3, 4, and 5 during one week (usually the sixth or seventh week) of the college quarter.
2. Assign our students to teams of three or four members according to certification level.
3. Assign each team to a class on an appropriate grade level. Early Childhood majors are in grades 3 and 4, Middle Grades majors are in 3, 4, and 5. (**See Appendix E, Teaching Assignments**)
4. Construct a hand-out for students that outlines arrangements. (See **Appendix E, Information For Long Branch Elementary Field Experience**)

5. Provide to the Principal of the school a letter to cooperating teachers that outlines the plans for the teaching experience.
6. Make an initial selection of activities from which students assigned to each grade level will choose the activities for that grade level. (See **Appendix E, Bibliography of Activities**)

On a Friday during the first part of the quarter, a class meeting is devoted to discussing the process for implementing the field-based component. At that time students receive details of the experience and a format for lesson plans. Working in groups according to assigned grade level, they choose activities to use in classrooms from those initially identified by the instructor.

The recommended format for lesson plans is in **Appendix E**. Students are allowed to deviate from the column format of this form; however, the format used must have the same parts as those in the recommended form. Students are urged to write mathematics or science objectives as they appear in the Quality Core Curriculum rather than try to state objectives in their own words. An approximate time, the number of the objective (from the list at the top of the page), materials, and evaluation must be keyed to each activity. Students in a team may work together to construct a set of plans; however, each student must submit his/her own set of plans. Lesson plans within a set should be consistent in style even if lessons are written by different students.

Prior to teaching in the classroom, students must submit two lessons and a calendar of activities for all five days to the instructors, who use the **Lesson Plan Preliminary Evaluation** form for providing written comments and suggestions to each student. This form has been developed through noting typical problem areas in initial lesson plans. No score or letter grade is given on this form. The formative evaluation provided at this stage allows students to refine their plans before using them in the classroom and submitting them for a grade.

Following the teaching experience, students submit a set of lesson plans consistent with the requirements on the **Lesson Plan Final Evaluation** form and a **Reflection Log** (**Appendix E**). Each lesson plan is graded by one instructor, as indicated on the page of **Teaching Assignments**, but the two instructors compare notes and discuss the quality of each set of lesson plans before returning them with a written evaluation.

Writing the Reflection Log is an opportunity for the student to practice metacognition while engaged in the teaching experience. If the writing is accomplished on a daily basis, the student will analyze the lesson to determine which instructional strategies and management techniques were effective and make necessary changes in the next day's lesson. Assessing the Reflection Log is part of the final evaluation of the set of lesson plans.

Appendix E contains the evaluation instruments for the classroom teaching portion of the field-based experience. Both instructors attempt to observe each student, although they concentrate in particular on the students in the classes for which they are responsible on the Teaching Assignment sheet. The form entitled **Student Evaluation** is completed by the instructors and the classroom teacher for each student.

During the week following the teaching experience, the two instructors meet to determine a composite evaluation for each student. The form **Evaluation of Teaching Performance** is used to return feedback to each student. Written comments selected from the remarks on the two pages following this form in **Appendix E** are attached to each

evaluation form before it is returned to the student. The comments, under the headings Positive Comments and Improvement Needed, have been developed over three quarters of observations during the field-based portion of these classes. Individualized comments for students who perform unusually well or who have special needs for improvement are added in some cases.

Resource Units

Students in both Mathematics 310 and Physics 460 create a resource unit (file). They receive information about creating the unit for each course at a meeting on the second Friday of the quarter. The written information for each course (see **Appendix F**) consists of the following parts:

1. A description of the resource unit, including the number of activities to prepare, the format, and other requirments. Instructions are provided for entering each unit in WordPerfect® on the network in the college Computer Lab.
2. The **Resource Unit Evaluation** form, indicating the criteria on which each unit will be assessed.
3. A sample activity written in the format required.

The requirements for the two units which are different reflect variations in instructional practice in the two content fields and possible differences in the assessibility of instructional materials for students.

Content Tests

Sample tests for each course are provided in **Appendix G**. As in all other phases of the courses, the intructors attempt to model current trends in evaluation. A recent publication of the National Research Council lists the following principles for selecting assessment tasks in mathematics (National Research Council, 1993)

1. **Mathematical content**: Reflect the "spirit" of the reform movement.
2. **Mathematical connections**: Develop links with science, social sciences, language arts, fine arts, and everyday life.
3. **Thoughtful approaches**: Promote "higher-order" thinking.
4. **Mathematical communication**: Emphasize the importance of communicating mathematical representations and chains of thinking more than isolated answers.
5. **Rich opportunities**: Let students solve problems with a variety of strategies, demonstrate talents, invent mathematics, apply mathematics, and show what they can do (rather than what they cannot do).
6. **Improved instruction**: Choose tasks that can influence instruction positively both from the teacher's and the students' viewpoints.

Although these recommendations apply to assessment of mathematics content, they could be modified slightly to describe assessment in science as well.

To model assessment procedures, the instructors have developed a number of evaluation methods. Instruments already described were created to assess lesson plans, classroom teaching performance, and resource units. In addition, each instructor administers three written tests each quarter. Because classes are scheduled for two hour periods, students have sufficient time to complete tests in a thoughtful manner.

An examination of the sample tests for both courses in **Appendix G** reveals that the instructors use a variety of item formats. Included in tests are the following types of items:

1. Multiple choice
2. True or false (in some cases, counterexamples are required for false statements)
3. Short answer and fill in the blank.
4. Draw and label diagrams
5. Give an example
6. Apply properties and principles
7. Solve problems, including a description of the strategy used
8. Explain how to use teaching aids and strategies
9. Show the steps in a thinking process
10. Measure different attributes of real objects

In addition to providing a variety of formats, instructors allow students to use models and teaching aids during the examination period. The models and aids are like or similar to ones that have been used during cooperative small group activities.

A pretest (**Appendix G**) was created and administered to students enrolled in MATH 310 at the first class meeting for two quarters. The test was constructed by selecting problems at the end of each chapter in an eighth grade textbook used by several school systems in the area. The mean score across the two quarters was about 50%.

Items number 13 through 20 were particularly difficult for the students. In order to help students learn the concepts and skills represented in these items, measurement knowledge and skills (item number 13) are incorporated in PHYSICS 460 and some elementary geometry (items number 14 and 15) is included in MATH 310. In order to fill in gaps in knowledge represented in items number 18 through 20, students who complete their core courses at North Georgia College learn about permutations, combinations, and probability in MATH 101, Finite Mathematics. Students are also required to complete MATH 240, Elementary Statistics, (see item number 17) before enrolling in MATH 310.

Problems Associated with Integrating the Courses

Problems almost always arise when the curriculum is changed. Some of the problems, such as those associated with scheduling, can be solved over a period of time. Others, such as content background of students, seem to persist over time.

Initially an important problem was related to insuring a common student population in both courses. During the first quarter of the project, the intersection of the two sets of students was small; therefore, the total number was large. Fifty-five students were placed in the field-based experience. This number overwhelmed the elementary school and created problems of supervision. Since each student only taught one lesson of 45 or 50 minutes each day and the instructional time periods for the three grades overlapped each other, the instructors were not able to observe individuals properly. In addition, the number of resource units and teaching units to be graded resulted in an overload of paperwork for the instructors, who were already spending a great deal of time in conferring and coordinating the multiple activities associated with the course.

The total number of students has been reduced over the last three quarters; however, some students are only enrolled for one of the courses, even now. The most common logistical reasons for not enrolling

in both courses are the following:

1. The student has transferred from another college or another major and has not established a plan of study that follows a logical sequence.
2. The student is attempting to complete a program in the shortest possible time and needs five hours of credit rather than ten hours during a particular quarter to carry a 15 quarter hour class load.
3. The student's grade was D or F in one of the courses during a previous quarter.

By Spring Quarter 1994 the two classes will both be scheduled for Monday through Friday from 1:00 p.m. to 3:00 p.m. Although a few students may still be in only one course because of being "out of phase," the instructors expect all students enrolled in either class to be available all five days for the entire instructional period.

A second problem that continues to surface is a pedagogical one. Some students resist enrolling for the two courses in the same quarter because they fear mathematics and/or science. **Appendix H** includes selected comments from students in response to a survey completed at the end of Spring Quarter 1993. Some students believe that they are at a disadvantage if they must complete both courses during the same quarter. Because the prospects of employment in teaching grades K-8 are not bright, students view a grade below B as a serious detriment to their future success; therefore, they are reluctant to enroll in two "difficult" courses during the same quarter.

Offering the two courses in the summer presents unique problems. Currently the two are offered as separate courses, but students are told that they must register for both because they will no longer be allowed to take them as separate courses during the other three quarters. Currently no field experience is available during the summer in our area. Even if there were opportunities for field experiences, the eight-week summer session is too short to accommodate an entire week of activities outside the college classroom. Despite the differences between the summer course offerings and the academic year block, the courses will continue to be offered in the summer to meet student scheduling needs.

Student access to instructional materials is a problem on our campus that other colleges may have already solved. Our educational curriculum library does not have sufficient resources, staff, or space to allow students to have access to many current instructional materials. Some of the materials that they need are not considered appropriate college library holdings, e.g. textbooks for grades K-8. If materials that belong to departments or individual faculty members are placed on reserve in the library, they are not then available for faculty to use in preparing instruction and undertaking research. The ideal solution of providing a library of instructional materials along with a production laboratory is not an option that will be available in the near future on our campus; therefore, students are required to prepare only a minimal resource unit. The instructors rely heavily on other means of introducing students to professional organizations, curriuclum projects, and supplementary instructional materials.

Student Opinions of the Courses

Despite the problems created by departing from traditional course organization, the instructors are optimistic that the current arrangement of integrating mathe-

matics and science is an improvement over offering two separate courses. In order to assess student reactions to the current state of development of the courses, the instructors asked students in MATH 310 to complete a survey form at the end of Spring Quarter 1993. (See **Appendix H**) The numerical data is separated into information collected from those enrolled only in MATH 310 and those enrolled in both MATH 310 and PHYSICS 460.

Representative comments were selected to indicate both positive and negative viewpoints about blocking the two courses, participation in cooperative small group activities, participation in the field-based component, and changes that should be made in the courses.

Some general observations can be made about the comments. Students who are only enrolled for MATH 310 are at a disadvantage because the other students are gaining information in PHYSICS 460 which they do not have. Some students find the content too easy, and others find it too difficult. Some comments show clear differences between those who are in a classroom setting for the first time and those who are more advanced in the program. Some students enjoy working in cooperative small groups, and some students prefer working alone.

Several themes are evident throughout the comments. Many students do appreciate the extra efforts that the instructors make to plan a reasonable schedule of assignments and tests, integrate the content of the two fields, introduce models and teaching aids through demonstrations and hands-on activities, and insure an opportunity to work with children in a real world setting. In addition, some students have worthwhile suggestions for changes to make in the future.

References

American Association for the Advancement of Science (1989). *Science for All Americans*. Washington D.C.: The Author.

McBride, J. W., and Silverman, F. L. Integrating elementary/middle school science and mathematics. *School Science and Mathematics*, 1(7), pp. 285 - 92.

National Council of Teachers of Mathematics (1989). *Curriculum and Evaluation Standards for School Mathematics*. Reston, VA: The Author.

National Research Council (1989). *Everybody Counts: A Report to the Nation on the Future of Mathematics Education: Summary*. Washington, D.C.: National Academy Press.

National Research Council (1993). *Measuring Up: Prototypes for Mathematics Assessment*. Washington, D.C.: National Academy Press.

National Science Teachers Association (1992). *NSTA Standards for Science Teacher Preparation: Final Draft*. Reston, VA: The Author.

APPENDIX A

BEST COPY AVAILABLE

Course Title: Number Systems for Teachers
Course Number: Mathematics 310
5 Credit Hours

Prerequisites: Ten hours of college level mathematics, to include the equivalent of Math 240, and junior or senior standing. Concurrent enrollment in Physics 460 is required for undergraduate students majoring in Early Childhood, Middle Grades Education, and Special Education.

Quarter:
Instructor: Rosalie Jensen, Ph.D.
Office: Dunlap 305B
Office Hours:

Textbook:

Philosophical Basis: In order to teach mathematics effectively in grades K-8, a teacher must understand mathematics on a higher level than that of the students being taught. Understanding elementary mathematics includes:

1. Solving problems using a variety of strategies.
2. Applying mathematics to real world situations and to other content areas.
3. Knowing terminology and symbols.
4. Appreciating the structure and power of our numeration system.
5. Being able to use properties of operations and relations and to perform algorithms for computations on whole numbers, fractions, decimals, integers, and rational numbers.
6. Identifying and applying the properties of geometric figures.
7. Using measurement for length, area, capacity, volume, weight/mass, time, and temperature.

Given an understanding of the basic concepts and processes which are related to mathematics, the teacher must be able to identify appropriate objectives for children at a given developmental stage, select proper strategies for developing mathematical concepts and skills, organize time and materials for effective teaching, analyze student errors, plan for remediation and enrichment, and assess students' knowledge and ability to apply content. Because of limitations in the mathematical knowledge of many of the students who enroll in this course, the instructor must balance the need for developing mathematics content with the need for introducing aspects of the teacher's role in the classroom. As a consequence, modeling the teaching of mathematics plays an important part in the organization and presentation of content.

Course Objectives: The student will:
1. Know and apply notation and terminology related to sets, whole numbers, fractions, decimals, integers, rational numbers, geometry of the plane, and measurement in the customary and metric systems.
2. Select and apply problem solving strategies related to number and numeration systems, elementary geometry, and measurement.

3. Identify and apply properties of our numeration system.
4. Identify and apply properties of operations and relations on whole numbers, fractions, decimals, and integers.
5. Identify and apply properties of geometric figures in the plane.
6. Estimate and make measurements and convert from one unit to another within the customary system and the metric system.
7. Relate objectives from the Quality Core Curriculum (QCC) to specific mathematics content.
8. Design a teaching unit (select strategies, organize time and materials, etc.) appropriate for a specific group of students in an elementary or middle school classroom.
9. Teach five days of lessons to a small group of students in an elementary or middle school classroom.
10. Use metacognitive processes to analyze errors on tests and plan for personal learning of skills and mathematical concepts.
11. Analyze systematic errors of students from work samples and recommend strategies of remediation based on types of errors.
12. Design a resource unit that includes activities to meet selected objectives from the QCC at one grade level.

Course Procedures: The instructor will use a variety of instructional methods so that students will:

1. Gain knowledge through lectures, demonstrations, and discussions.
2. Gain practice through working exercises at the end of each section and chapter in the textbook.
3. Develop critical thinking skills through class discussions and small group cooperative activities.
4. Explore the wisdom of practice through reading the textbook and examining materials designed to be used in teaching mathematics to students K-8.
5. Explore the state curriculum by examining Georgia QCC objectives and select activities to match these objectives.
6. Gain practice in selecting strategies and organizing time and materials through working with students in a local middle or elementary school.
7. Engage in activities with materials representing manipulative, pictorial, and symbolic levels of developing mathematics content. Materials include calculators, measuring devices, base blocks, colored rods, fraction pieces, geoboards, dot paper, and grid paper.
8. Evaluate own progress through analyzing results of tests and assignments.

Tests: Tests will include problem solving, constructed answer, multiple choice, and short answer items. No partial credit will be awarded on multiple choice and short answer items, and only the response written in the blank will be considered. Partial credit will be considered on problem solving and constructed answer items on which a correct method is employed but mistakes are made in arithmetic. Multiple choice items will

serve as a model for the type of items that students will encounter on the Georgia TCT. Calculators may be used at any time during the quarter, and students should bring two pencils and a calculator to each test.

Assignments: A schedule of pages to read and exercises to work in the textbook will be included on the outline distributed at the beginning of the development of each chapter.

Projects: A detailed description of each project will be distributed at intervals during the quarter to allow for discussion of the nature of the assignment. Projects include participation in large group, small group, and individual activities during class, creating a resource unit, preparing a teaching unit, and teaching the content of the unit to students at a school in the Dahlonega area.

Evaluation: See the **Student Evaluation** form for details related to tests and assignments. The final grade for each student will be based on the following plan:

Items	Points
3 Tests @ 100 pts.	300
Projects	
Class Activities	30
Resource Unit	20
Field Component	50
Total	400

Total Points	Percent	Grade
360 - 400	90 - 100	A
320 - 359	80 - 89	B
280 - 319	70 - 79	C
240 - 279	60 - 69	D
Below 240		F

Math 310
Student Evaluation Form

_____ Quarter

_____ Student Name

A. Tests (100 points each)

Test #	Textbook Sections	Date	Score
1			
2			
3			
		Total	

B. Attendance and Participation (30 points) Total _____

C. Resource Unit (20 points) Total _____

Grade Level

D. Lesson Plans and Field Activities (50 Points)

Lesson Plans (25 points) _____

Classroom experience (25 points) _____

Total _____

Final Grade _____

Course Title: Science for Elementary School Teachers
Course Number: Physics 460
5 Quarter Hours

Prerequisites: Science Core complete. Concurrent enrollment in Mathematics 310 is required for undergraduate students majoring in Early Childhood, Middle Grades Education, and Special Education.

Quarter:
Instructor: Susan P. Gannaway, Ed.D.
Office: Education 306
Office Hours:

Textbook:

Catalog Description: This course is for teachers of grades K-8. A course dealing with the everyday aspects of physics, chemistry, and astronomy as they will need to be explained by the elementary teacher. The work will include demonstrations and experiments which can be performed with readily available materials.

Philosophical Basis: Science is a way of knowing about, understanding, interacting with, and appreciating the natural world. K-8 students and teachers need ample opportunities to do just that. During this course students will learn content, primarily from physics, needed to teach selected areas of the K-8 QCC in science. Methods used in teaching will model the "hands on" process-oriented science recommended for use in primary and middle grades. These experiences are consistent with the learning cycle approach to science teaching as well as a constructivist view of knowledge. Students will experience, reflect on and experiment with these methods, both as learners and as teachers so that they will be prepared to serve as models of exemplary methods when they enter the schools. Both the content and the experience with methods will enable the students to facilitate learning in science as they become teachers. Curriculum, organizational skills and safety considerations will be introduced as a part of the decision making process for elementary and middle grades science.

Course Objectives: The student will demonstrate the ability to:

1. Fulfill the student content objectives related to motion, measurement, machines and forces, heat and energy, and electricity and magnetism as described in the K-8 QCC.
2. Fulfill additional content objectives provided by the instructor.
3. Identify current and historical trends in elementary school science education in Georgia and the nation.
4. Plan for and implement developmentally appropriate hands-on science activities.
5. Identify the characterisitics of exemplary elementary school science programs.
6. Identify and use methods for assessing science programs and instruction.
7. Identify and use sources of science curricula and equipment and make decisions about local needs and acquisitions.
8. Organize classrooms and storage areas for safe and efficient instruction.

9. Identify, use, and/or participate in professional programs and literature.
10. Use science process skills and metacognitive processes to assess oneself as a learner and teacher of science.
11. Identify the interrelationships between mathematics and science curricula, and use those relationships to plan integrated instruction.

Course Procedures: The instructor will use instructional methods so that the students will experience:

1. Establishing and participating in cooperative learning experiences.
2. Planning and participating in science lessons organized around the learning cycle and rich in experience.
3. Identifying and using students' self constructed theories which can be tested against evidence in a flexible atmosphere which encourages inquiry, exploration, testing of ideas, and risk taking.
4. A variety of methods for assessing and evaluating student achievement.

Evaluation: Grades in the course will be calculated on a total point basis. Points will be assigned to various kinds of assignments, and the final letter grade will be determined from a percentage of the total possible number of points. The percentage required for an A will not exceed 90% of the total; for a B, 80%; for a C, 70%; and for a D, 60%.
At present, the following point distribution is expected:

Tests (3, including final)	300
Teaching unit	50
Resource unit	25
Projects, daily grades	125
Total	500

Detailed instructions will be provided for the teaching unit, the resource unit and other activities at the appropriate time. Please note that the bulk of the graded assignments occur in the second half of the quarter because students will need instruction before being able to carry them out.

September 20 - October 29, 1993

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Sept 20	Sept 21 M310-Numeration, Calculators Drop/Add	Sept 22 ***Autumn begins*** P460-Systems of Measurement	Sept 23 M310-Sets	Sept 24 Both-Problem Solving/ Process Skills
Sept 27 310-Patterns and Sets	Sept 28 M310-Whole Number, Addition and Subtraction	Sept 29 P460-Length & Area, Rounding & Recording Data	Sept 30 P460-Mass and Volume	Oct 1 P460-Resource Units, Organization of Curriculum
Oct 4 2460-Density, Time, Temperature	Oct 5 M310-Whole Number Multiplication	Oct 6 Honors Convocation	Oct 7 M310-Review	Oct 8 ***Science Test 1**** Both-Introduction to Field Experience
Oct 11 ***Columbus Day (Observed)*** 460-Force and Motion; Vectors	Oct 12 ***M310-Test 1**** Gold Rush	Oct 13 P460-Velocity and Acceleration	Oct 14 M310-Whole Number Division, ****Preliminary Plans Due***	Oct 15 No Class, Science Conference
Oct 18 460-Gravity	Oct 19 M310-Factors and Multiples	Oct 20 P460-Machines, Work & Mechanical Advantage	Oct 21 M310-GCD and LCM	Oct 22 P460-Machines and Mechanical Advantage
Oct 25	Oct 26 Field Experience	Oct 27 Field Experience	Oct 28 Field Experience	Oct 29 ****Final Plans & Reflection Logs Due***

November 1 - December 10, 1993

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Nov 1 P460-Heat and Energy	Nov 2 *Election Day* M310-Integers	Nov 3 P460-Kinetic Theory, Changes in State, ***Science Units Due**	Nov 4 M310-Fractions	Nov 5 Winter Advisement ***Science Test 2***
Nov 8 P460-Magnets & Compasses	Nov 9 M310-Operations on Fractions, ***Math Unit Due**	Nov 10 P460-Forces and Fields	Nov 11 *Veterans Day* ***M310-*Math Test 2***	Nov 12 No Class
Winter Advisement				
Winter Registration				
Nov 15 P460-Magnet Applications	Nov 16 M310-Decimals	Nov 17 P460-Batteries and Bulbs	Nov 18 M310-Operations on Decimals	Nov 19 M310-Ratio, Percent
Nov 22 P460-Resistors, Switches, Electromag	Nov 23 M310-Introduction to Geometry	Nov 24 Study Day	Nov 25 *Thanksgiving*	Nov 26
			Thanksgiving Break	
Nov 29 P460-Series and Parallel Circuits	Nov 30 M310-Motion Geometry	Dec 1 Last Day of Classes P460-Power Generation	Dec 2	Dec 3
			Final Exams	
Dec 6 Grades Due-12 Noon	Dec 7	Dec 8	Dec 9 *Hanukah*	Dec 10

APPENDIX B

BEST COPY AVAILABLE

MATHEMATICS 310

Session 1 **3.1 Numeration Systems**

Concepts.

numeral
numeration system
base
base ten numeration system
digits
expanded forms
powers of 10
place value
period
rounding

Teaching Aids and Models

base ten blocks
bundles of sticks
calculators
Cuisenaire rods
hundreds chart
pennies, dimes, and dollars
place value charts
Unifix Cubes

In Class

"Detective's Delight"
"Happy Message," *Arithmetic Teacher*, IDEAS, Feb 1989.
"How Many," *IDEAS from the Arithmetic Teacher: Grades 1-4, Primary*, Immerzeel
"How Big Is A Thousand? How Much Is Ten Dollars"
"Make My Number"
"Wipeout"
Selected activities from *Building Understanding With Base Ten Blocks (Primary)*, McLean

Session 2 **2.1 Sets and Counting**

Concepts

set
element
empty set, null set
Venn diagram
disjoint sets
subset
proper subset
equal sets
one-to-one correspondence
equivalent sets

same number
count
finite set
intersection of sets (and)
union of sets (or)
exclusive "or"
inclusive "or"
complement of a set
universal set
infinite set

Notation (see the symbols in your textbook)
methods of specifying a set
describing the elements (verbal description)
listing the elements (list of elements)
empty set, null set
element of a set, not an element of a set
subset
intersection of sets
union of sets

Teaching Aids and Models
attribute pieces (pieces cut from patterns)

Problem Solving Strategy
Use a Venn diagram

In Class
Activities with attribute pieces (Materials Sheet 1)
Selected problems from *Cooperative Problem Solving with Calculators*, Roper.

Session 3 **1.1 Introduction to Problem Solving**

Concepts
problem
problem solving

Problem Solving Strategies
Make a drawing
Guess and check
Make a table
Use a model
Work backward

Steps in Problem Solving
1. Understand the problem
2. Devise a plan
3. Carry out the plan
4. Look back

In Class

"Create a House Number," IDEAS, *Arithmetic Teacher*, Jan 1989.

"Problem Solving Tic-Tac-Toe," *Arithmetic Teacher*, Nov 1978.

Selected problems from:

Cooperative Problem Solving With Calculators, Roper.

HANDS ON: Unifix Cubes, Book 1, Creative Publications.

Successful Problem Solving Techniques, Greenes.

Session 4 **1.2 Patterns and Problem Solving**

Concepts

even number
odd number
Pascal's Triangle
common difference
arithmetic sequence
common ratio
geometric sequence
triangular number
inductive reasoning
counterexample

Problem Solving Strategies.

Solve a simpler problem
Find a pattern

In Class

"Hundred Chart: Rows and Columns" and "Hundred Chart: More Patterns," *Mathematics Teacher*, Jan. 1991.

"Party Guests"

Session 5 **3.2 Addition and Subtraction**

Concepts

sum +
addends
algorithm
less than <
greater than >
less than or equal to $\leq$
greater than or equal to $\geq$
inverse operations
difference of r minus s
take-away concept
comparison concept
error analysis

Properties

Let a and b be whole numbers: .

closed (closure) for addition	a + b is a unique whole number
identity for addition	a + 0 = 0 + a = a
commutative for addition	a + b = b + a
associative for addition	a + (b + c) = (a + b) + c

Algorithms

- partial sums
- left-to-right (scratch method)

Teaching Aids and Models

- addition table
- base ten blocks
- number line
- Unifix cubes

Mental Calculations

- compatible numbers
- substitutions (associative property)
- equal differences

Estimation Techniques

- rounding
- compatible number
- front-end estimation

Problem Solving Strategy

- Make an organized list

In Class

- **"Blank Boxes - 1"**
- **"High Draw"**
- **"Pilgrim Puzzler,"** *Arithmetic Teacher*, IDEAS, Nov 1986
- **"Turtle Trot,"** *Arithmetic Teacher*,
- Selected activities from:
  - *Building Understanding With Base Ten Blocks: Primary*, McLean
  - *CALCULATE! Problem Solving With Calculators: Whole Number Operations*, Coburn
  - *Calculator Workjobs: Four Function*, Charles
  - *Cooperative Problem Solving With Calculators*, Roper
  - *Primary Cooperative Problem Solving With Base Ten Blocks*, Hoogebloom

Session 7 **3.3 Multiplication**

Concepts
- multiplication of whole numbers
- repeated addition
- product of r times s
- factors
- partial products
- lattice multiplication
- order of operations
- error analysis

Properties

Let a and b be whole numbers:

closure (closed) for multiplication	a x b is a whole number
identity property	a x 1 = 1 x a = a
commutative property	a x b = b x a
associative property	a x (b x c) = (a x b) x c
distributive property of multiplication over addition	a x (b + c) = (a x b) + (a x c)

Teaching Aids and Models
- base ten blocks
- base ten paper
- number line
- repeated addition
- rectangular array
- tree diagram

Mental Calculations
- compatible numbers
- substitutions (distributive property)
- equal products

Estimation Techniques
- rounding
- compatible numbers
- front-end estimation

In Class
- **"Amazing Multiplication,"** IDEAS, *Arithmetic*, May 1987
- **"Blank Boxes - 2"**
- **"Calculator Counting,"** IDEAS, *Arithmetic Teacher*, Oct 1987
- **"Match the Number Tags,"** *IDEAS from the Arithmetic Teacher: Grades 4-6, Intermediate School*, Immerzeel
- **"Play Estimating Computation,"** *IDEAS from the Arithmetic Teacher: Grades 6-8, Middle School*, Immerzeel
- **"Shorts and Shirts,"** IDEAS, *Arithmetic Teacher*, Sept 1988

"Table Patterns," IDEAS, *Arithmetic Teacher*, Feb 1988
Selected activities from:
Building Understanding With Base Ten Blocks: Middle, McLean
CALCULATE! Problem Solving With Calculators: Whole Number Operations, Coburn
CALCULATOR JOBCARDS: Four Function, Charles

Session 8 **Review for Test 1**

Session 9 **Introduction to Field Experience**

Session 10 **Test 1**

Session 11 **3.4 Division and Exponents**

Concepts
- division of whole numbers
  - inverse of multiplication
- dividend
- divisor
- quotient
- partitive (sharing) concept
- measurement (subtractive) concept
- remainder
- exponent
- exponential form
- nth power of b
- perfect squares
- perfect cubes
- division involving zero

Algorithms
- long division
- order of operations

Division Algorithm
- Division Algorithm
  - For any whole numbers a and b, with $b \neq 0$, there are whole numbers q and r such that $a = bq + r$ and $0 \leq r < b$.

Teaching Aids and Models
- base ten blocks

Mental Calculations
- equal quotients

Estimation
- rounding
- compatible numbers
- front end estimation

Laws of Exponents

$a^m \times a^n = a^{m+n}$

$a^m \div a^n = a^{m-n}$ for $a \neq 0$

Using Calculators
- raise to a power
  - four function calculator
  - scientific calculator
- order of operations
  - four function calculator
  - scientific calculator

In Class
- "Bowl-A-Fact," *Measuring Up: Prototypes for Mathematics Assessment*, National Research Council
- "Estimating Millions"
- "Five Come Alive"
- Selected activities from:
  - *Building Understanding With Base Ten Blocks*, McLean
  - *CALCULATE! Problem Solving With Calculators: Whole Number Operations*, Coburn
  - *CALCULATOR JOBCARDS: Four-Function*

Session 12 **4.1 Factors and Multiples**

Concepts
- triangular numbers
- number theory
- factor
- multiple
- divides (a|b if a is a factor of b)
- divisible by
- even number
- odd number
- prime number
- composite number
- twin primes

Teaching Aids and Models
- linear model
- rectangular model (use small base blocks or Unifix Cubes)
- sieve of Eratosthenes
- Cuisenaire Rods

Divisibility Theorems

1. If a|b and a|c, then a|(b + c).
2. If a|b and a|c, then a|(b + c).
3. If a|b, then a|kb.

Tests for Divisibility

tests for 2 and 5
tests for 3 and 9
test for 6
test for 4
test for 11

Prime Number Test

Suppose n is a whole number and p is a prime such that p > n. If there is no smaller prime that divides n, then n is a prime number.

In Class

Use units from base blocks or Cuisenaire rods or use Unifix Cubes:

"Even Splits," *IDEAS from the Arithmetic Teacher: Grades 1-4, Primary*, Immerzeel

"IDEAS for Number Patterns," *IDEAS from the Arithmetic Teacher: Grades 6-8, Middle School*, Immerzeel

Find prime numbers less than 100 by Sieve of Eratosthenes

"Number Round Up," IDEAS, *Arithmetic Teacher*, Feb. 1989

"Secret Number"

"Top Secret," *IDEAS from the Arithmetic Teacher: Grades 4-6, Intermediate School*, Immerzeel

"Who's on First?" IDEAS, *Arithmetic Teacher*, Oct. 1991

Session 13 **4.2 Greatest Common Divisor (GCD) and Least Common Multiple (LCM)**

Concepts

prime factorization
common factor
greatest common factor (GCF)
least common multiple (LCM)
relatively prime

Fundamental Theorem of Arithmetic

Every composite number has one and only one prime factorization (if the order of the factors is disregarded).

Teaching Aids and Models

Cuisenaire rods or Unifix cubes
factor tree
number line

LCM Theorem

For any positive whole numbers a and b,

$$LCM(a, b) = \frac{a \times b}{GCF(a, b)} \text{ and,}$$

when GCF(a, b) = 1, LCM(a, b) = a x b.

In Class

"Fun with Factors"
"A Prime Formula"
"Practice with Divisibility"
"Prime Triangles"
"What Number Am I?"

Session 14 **5.1 Integers**

Concepts

negative whole number
integers
opposite, negative of
positive integers
negative integers
addition of integers
subtraction of integers
adding opposites
multiplication of integers
division of integers
opposite, or inverse for addition, of an integer

Applications

credits and debts
temperature
sports
time
altitude

Teaching Aids and Models

black and red chips
number line
patterns (multiplication)

Rule of Signs

addition
multiplication
subtraction
division

Properties of Integers

commutative
associative
distributive
closure
identity
inverse for addition

In Class

"Magic Squares: Sheet 3," *Activities from the Mathematics Teacher*, Maletsky

Selected activities with red and black chip model (addition, subtraction, and multiplication)

Session 15 **5.2 Introduction to Fractions**

Concepts

unit fractions
fraction
denominator
numerator
part-to-whole concept
fraction as a quotient of two numbers
fraction as a ratio
equal fractions
simplifying fractions
simplified form
simplest form, lowest form
common denominator
smallest common denominator
dense
improper fractions
mixed numbers

Teaching Aids and Models

Cuisenaire rods
fraction bars
fractional parts of regions (circular, rectangular)
paper strip number line (paper folding)

Tests for Equality and Inequality of Fractions

For any fractions **a/b** and **c/d**,

$$\frac{a}{b} = \frac{c}{d} \text{ if and only if } ad = bc$$

For any fractions **a/b** and **c/d**, with **b** and **d** positive,

$$\frac{a}{b} < \frac{c}{d} \text{ if and only if } ad < cd$$

$$\frac{a}{b} > \frac{c}{d} \text{ if and only if } ad > cd$$

Mental Calculation and Estimation

use pictorial models
rounding, using whole numbers and 1/2
replace each fraction by a close approximation

In Class

From *Curriculum and Evaluation Standards for School Mathematics Addenda Series: Developing Number Sense in the Middle Grades*, NCTM:

"Estimating Fractions Between 0 and 1"
"Fraction Hunt"
"Sorting Fractions"

IDEAS for Fractions, pp. 45 and 53, *IDEAS from the Arithmetic Teacher: Grades 4-6, Intermediate*, Immerzeel

"Team Play," Arithmetic Teacher, Jan 1988

Session 16 **5.3 Operations with Fractions**

Concepts

- addition
  - same denominator
  - unlike denominators
  - definition
  - mixed numbers
- subtraction
  - same denominator
  - unlike denominators
  - definition
  - mixed numbers
- multiplication
  - whole number times a fraction
  - fraction times a whole number
  - fraction times a fraction
  - definition
- division
  - measurement concept
  - fractions having same denominator
  - definition

Properties

closed (closure)	(+ and x)
identity	(+ and x)
commutative	(+ and x)
associative	(+ and x)
distributive	(x over +)
inverses	(+ and x)

Teaching Aids and Models

- fraction bars
- fractional parts of regions
- paper strip number line
- rectangular region model for multiplication

In Class

"Team Play," IDEAS, *Arithmetic Teacher*, Jan 1988.
Selected activities with paper strip number lines and fractional parts of regions

Session 17 Test 2

Session 18 **6.1 Decimals and Rational Numbers**

Concepts

decimal
decimal point
number of decimal places
place values
opposite (inverse for addition)
equality of decimals
inequality of decimals
rational numbers
terminating (or finite) decimals
repeating decimal
dense

Teaching Aids and Models

base ten blocks
decimal squares
number line

Estimation

rounding
Rule for rounding numbers

In Class

"Number Detective," *Curriculum and Evaluation Standards for School Mathematics Addenda Series: Grade 5*, NCTM
Selected activities from *Building Understanding with Base Ten Blocks (Middle)*, Smart

Session 19 **6.2 Operations with Decimals**

Concepts

multiplying by powers or ten
dividing by powers of ten
order of operations
repeating decimals

Algorithms

addition
subtraction
multiplication
division

Properties
- closure
- commutative
- associative
- identity
- inverse
- distributive

Teaching Aids and Models
- decimal squares
- magic triangles and squares

Mental Calculations
- substitutions
- equal additions
- compatible numbers

Estimation
- rounding
- front-end estimation
- compatible numbers

In Class
- **"Magic Squares: Sheet 2,"** *Activities from the Mathematics Teacher*, Maletsky
- Activities from *IDEAS from the Arithmetic Teacher: Grades 6-8, Middle School*, Immerzeel:
  - **"Play Estimating Decimal Products"**
  - **"This is a Magic Square"**
- Selected activities from *Building Understanding with Base Ten Blocks (Middle)*, Smart

Session 20 **6.3 Ratio, Percent, and Scientific Notation**

Concepts
- ratio
- proportion
- percent
- scientific notation
  - mantissa
  - characteristic

Types of Percent Problems
- Given the whole and the percent, find the part.
- Given the whole and the part, find the percent.
- Given the percent and the part, find the whole.

Mental Calculations
- compatible numbers
- substitutions

Estimation
- compatible numbers

Teaching Aids and Models
- base ten blocks
- Cuisenaire rods
- decimal squares

Problem Solving Strategies
- Use proportional reasoning (golden rule)
- Solve an equation

In Class
- Activities from *Curriculum and Evaluation Standards for School Mathematics: Developing Number Sense:*
  - **"Percent of a Whole"**
  - **"Exploring Equivalent Expressions with Percents"**
- **"Applications of Percents"**
- **"Finding the Same Percent,"** *Activities from the Mathematics Teacher*, Hirsch
- Selected activities from *Building Understanding with Base Ten Blocks (Middle)*, Smart
- **"Paying Taxes,"** *Math Power in the Community*, Kuhm
- **"Percentages and Cuisenaire Rods,"** *Mathematics Teacher*, Nov 1990
- **"Play the Percentages,"** *Arithmetic Teacher*, Feb 1982

Session 21 **7.1 Plane Figures**

Concepts
- geometry
- mathematical system
  - undefined terms
  - axioms
  - definitions
  - theorems
- points
- line
  - collinear
- plane
  - half-planes
  - opposite half-planes
- line segment
  - endpoints
- bisect a line
  - midpoint
- ray
  - endpoint
  - half-lines
- angle
  - sides of an angle
- angle measurement
  - degree
  - protractor
- types of angles
  - right
  - acute
  - obtuse

relationships of angles
- complementary — supplementary
- adjacent — vertical

relationships of lines
- perpendicular — parallel

curve

types of curves
- simple — closed — simple closed

plane region
- convex — nonconvex

circle
- center — radius
- chord — diameter
- tangent — circumference
- disc

polygon
- polygonal region
- sides — vertices — diagonal

types of polygons (number of sides)
- triangle (3) — heptagon (6)
- quadrilateral (4) — octagon (7)
- pentagon (5) — decagon (10)
- hexagon (6) — dodecagon (12)

triangle
- right
- equilateral — scalene — isosceles

quadrilateral
- trapezoid — rhombus — parallelogram
- rectangle — square

Theorems

Jordan Curve Theorem. Every simple closed curve partitions a plane into three disjoint sets: the points on the curve, the points in the interior, and the points in the exterior.

Teaching Aids

geoboard and dot paper

In Class

Selected activities with geoboards and dot paper from:

HANDS-ON GEOBOARDS, (Books 1 and 3), Creative Publications

Dot Paper Geometry, Cuisenaire Co. of America

Session 22 7.2. **Polygons and Tessalations**

Concepts.

congruent
- line segments
- angles

regular polygons

Teaching Aids
geoboard and dot paper
paper and scissors

7.4. Symmetric Figures

Concepts
reflection symmetry
line of symmetry
image
rotation symmetry
center of rotation

Teaching Aids
paper and scissors

In Class
Fold and cut figures with one or more lines of symmetry.
"Hawaiian Quilt Patterns," *Mathematics Teacher*, April 1991
Fold, cut out, and count the number of symmetries of regular quadrilaterals and octagons.

MATHEMATICS 310

References

Arithmetic Teacher, IDEAS section:
"Amazing Multiplication," May 1987.
"Calculator Counting," October, 1987.
"Create a House Number," January, 1989.
"Happy Message," February, 1989.
"Number Round Up," February 1988.
"Pilgrim Puzzler," November 1986.
"Play the Percentages," February 1982.
"Problem Solving Tic-Tac-Toe," November 1978.
"Shorts and Shirts," September 1988.
"Table Patterns," February 1988.
"Team Play," January 1988.
"Turtle Trot," February 1988.
"Who's On First?" October, 1991

Artz, Alice and Newman, Claire (1990) *How to Use Cooperative Learning in the Mathematics Class*. Reston, VA: National Council of Teachers of Mathematics.

Charles, Linda (1991). *Calculator Jobcards: Four Function*. Sunnyvale, CA: Creative Publications.

Coburn, Terrence (1988). *CALCULATE! Problem Solving with Calculators: Whole Number Operations*. Sunnyvale, CA: Creative Publications.

Creative Publications (1986) *HANDS ON: Geoboards, Book 1*. Sunnyvale, CA: The Author.

Creative Publications (1987) *HANDS ON: Unifix Cubes, Book 1*. Sunnyvale, CA: The Author.

Cuisenaire Co. of America (1980). *Dot Paper Geometry*. White Plains, NY: The Author

Greenes, Carole, Gregory, John, and Seymour, Dale (1977). *Successful Problem Solving Techniques*. Palo Alto, CA: Creative Publications.

Hoogebloom, Shirley, and Goodnow, Judy (1991). *Primary Cooperative Problem Solving With Base Ten Blocks*. Sunnyvale, CA: Creative Publications.

Immerzeel, George and Thomas, Melvin (1982). *IDEAS from the Arithmetic Teacher: Grades 1-4, Primary*. Reston, VA: National Council of Teachers of Mathematics.

Immerzeel, George and Thomas, Melvin (1982). *IDEAS from the Arithmetic Teacher: Grades 4- 6, Intermediate School.* Reston, VA: National Council of Teachers of Mathematics.

Immerzeel, George and Thomas, Melvin (1982). *IDEAS from the Arithmetic Teacher: Grades 6-8, Middle School.* Reston, VA: National Council of Teachers of Mathematics.

Kulm, Gerald (1990) *Math Power in the Community.* Washington, DC: American Association for the Advancement of Science.

Learning Resources (1990). *Geoboard Activity Book for Primary Grades.* Deerfield, IL: The Author.

Maletsky, Evan and Hirsch, Christian (1981). *Activities from the Mathematics Teacher.* Reston, VA: National Council of Teachers of Mathematics.

National Research Council (1993). Measuring Up: Prototypes for Mathematics Assessment. Washington, DC: National Academy Press.

Mathematics Teacher, ACTIVITIES section:
"Hawaiin Quilt Patterns," April 1991.
"Hundred Chart: More Patterns," January 1991.
"Hundred Chart: Rows and Columns," January 1991.
"Percentages and Cuisenaire Rods," November 1990

McLean, Peggy, Laycock, Mary, and Smart, Margaret (1990). *Building Understanding with Base Ten Blocks: Primary.* Hayward, CA: Activity Resources Co, Inc.

McLean, Peggy, Laycock, Mary, and Smart, Margaret (1990). *Building Understanding with Base Ten Blocks: Middle.* Hayward, CA: Activity Resources Co, Inc.

National Council of Teachers of Mathematics. *Curriculum and Evaluation Standards for School Mathematics Addenda Series, Grades K-6.* Reston, VA: The Author. The series includes these books:

Kindergarten Book (1991)
First-Grade Book (1991)
Second-Grade Book (1992)
Third-Grade Book (1992)
Fourth-Grade Book (1992)
Fifth-Grade Book (1992)
Sixth-Grade Book (1992)
Geometry and Spatial Sense (1993)
Making Sense of Data: Addenda Series (1993)
Number Sense and Operations (1993)
Patterns (1992)

National Council of Teachers of Mathematics. *Curriculum and Evaluation Standards for School Mathematics Addenda Series, Grades 5-8.* Reston, VA: The Author. The series includes these books:

Dealing with Data and Chance (1991).
Developing Number Sense in the Middle Grades (1991).
Geometry in the Middle Grades (1992)
Patterns and Functions (1991)

National Council of Teachers of Mathematics. The following video tapes supplement other materials developed to support the *Standards:*

Mathematics: Making the Connection (1991)
Number Sense Now (1993).
Reaching Higher (1990).

Roper, Ann, Hoogeboom, Shirley, and Goodnow, Judy (1991). *Cooperative Problem Solving With Calculators.* Sunnyvale, CA: Creative Publications.

Smart, Margaret, McLean, Peggy, and Laycock, Margy (1990). *Building Understanding with Base Ten Blocks (Middle).* Hayward, CA: Activity Resources Co, Inc.

Webb, Norman, and Coxford, Arthur (1993). *Assessment in the Mathematics Classroom.* 1993 Yearbook. Reston, VA: National Council of Teachers of Mathematics.

SELECTED ACTIVITIES

APPLICATIONS OF PERCENTS

A. Application problems involving percents are usually in one of these form:

1. Finding a percent of a number.

   A house that sells for $72,000 requires a 20% down payment What is the amount of the down payment?

2. Finding what percent one number is of another.

   Dana has 45 correct answers on an 80-item test. What percent of her answers are correct?

3. Finding a number when a percent of that number is known.

   Forty-two percent of the pupils at Public Primary School travel to school on the school bus. If the number of pupils who come by school bus is 168, how many pupils attend the school?

B. Additional problems. We will begin working these in class. Please complete the ones you were not able to finish and bring your work tomorrow. Classify each problem according to the three types above before you solve the problem.

1. Sara bought a dress marked down 20%. If the regular price was $28.00, what was the sale price?

2. Juan weighed 9 pounds at birth. At 6 months, he weighed 18 pounds. What was the percent of increase in Juan's weight?

3. A car originally cost $8000. One year later, it was worth $6800. What is the percent of depreciation?

4. If a 1/4-cup serving of Munchies has 0.5% of the minimum daily requirement of Vitamin C, how many cups would you need to eat in order to obtain the minimum daily requirement of Vitamin C?

5. An airline ticket cost $320 without tax. If the tax rate is 5%, what is the total bill for the airline ticket?

6. Marian bought a bicycle and then sold it for 20% more than she paid for it. If she sold it for $144, what did she pay for it?

7. Snappy Clothing Store advertised a suit for 10% off, for a savings of $15. Later, they marked the suit at 30% off the original price. What is the amount of the current discount?

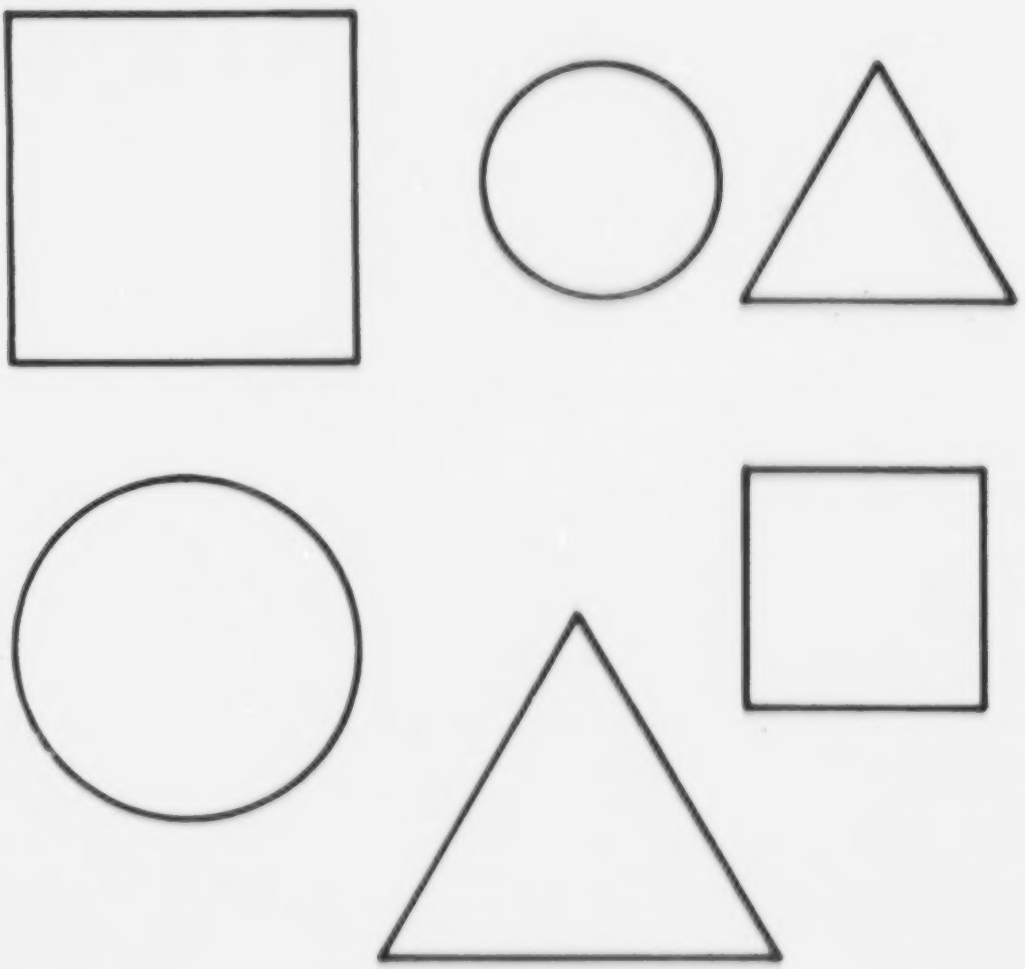
MATERIALS SHEET 1

ATTRIBUTE PIECES

Use these patterns in one of the following ways:

1. Cut out a copy of each of the 6 pieces on 4 colors of construction paper (red, blue, yellow, and green.)
2. Make three copies of this page. Color the shapes on one copy red, on one copy blue, on one copy yellow, and on one copy green. Cut out the pieces.

You should have 24 pieces in all. No two pieces should be alike in all three ways: shape, color, and size.



ATTRIBUTE PIECES ACTIVITIES

Materials. Copy of **Materials Sheet 1**

Activitiy

A. Separate your set of attribute pieces into **subsets** so that each subset has pieces of the same size. (**classification**)

1. How many subsets do you have? _____
2. How many pieces are in each subset? _____

B. Separate your set of attribute pieces into subsets so that each subset has pieces of the same color and size.

1. How many subsets do you have? _____
2. How many pieces are in each subset? _____

C. Let **A** = (all attribute pieces), **S** = (small pieces), **T** = (triangles), and **Y** = (yellow pieces).

1. Each piece has **size, color, and shape** and can be named by these three attributes. **Example.** The large green circle can be named **lgc**. Use correct set notation (braces {}) to list the elements of each set. **(communication)**

   a. **T** = _____

   b. **Y** = _____

   c. **T** ∩ **Y** = _____

2. Name the **number** of elements in each set. Note that **A** is the **universal set** and that the notation **S′** for any set **S** is the **complement** of that set.

   a. **A** ____ f. **T′** ____

   b. **T** ∩ **Y** ____ g. **T′** ∪ **Y** ____

   c. **T** ∪ **S** ____ h. **T′** ∩ **T** ____

   d. **Y** ∪ **A** ____ i. **Y′** ∩ **S** ____

   e. **T** ∩ **A** ____ j. **Y′** ∪ **Y** ____

3. Circle the pairs of sets that are **equivalent.**

   a. **S** and **S′** b. **S** and **T** c. **Y** and **Y′** d. **T** and **Y**

4. Are **T** and **T′** **disjoint**? _____

D. On the back of this page, list some objectives of these activities.

Blank Boxes - 1

Directions:
Using only the numbers 2,3,4, or 6 complete the following number sentences.

Example: ____ + ____ + ____ = 11
Solution: 2 + 3 + 6 = 11

1. ___ - ___ - ___ = 1
2. ___ - ___ - ___ = 0
3. ___ + ___ - ___ = 1
4. ___ + ___ - ___ = 3
5. ___ + ___ - ___ = 4
6. ___ - ___ + ___ = 5
7. ___ + ___ - ___ = 7
8. ___ + ___ - ___ = 8
9. ___ + ___ + ___ = 9
10. ___ + ___ + ___ = 12

Designed by Marion Fox

Blank Boxes - 2

Directions:
Using only the numbers 2,3,4, or 6 complete the following number sentences.

Example: ___ x ___ x ___ = 24
Solution: 2 x 3 x 4 = 24

1. ___ x ___ ÷ ___ = 12
2. ___ x ___ ÷ ___ = 1
3. ___ x ___ ÷ ___ = 2
4. ___ x ___ - ___ = 5
5. ___ x ___ x ___ = 72
6. ___ x ___ - ___ = 6
7. ___ x ___ ÷ ___ = 8
8. ___ x ___ ÷ ___ = 6
9. ___ - ___ ÷ ___ = 1
10. ___ x ___ + ___ = 20

Designed by Marion Fox

)ETECTIVE'S DELIGHT

)bjective

Using the elimination strategy to solve problems about number relations, place value, factors, multiples, primes and related concepts.

)ctivity

Write problems like the examples on a transparency or the chalkboard, revealing one clue at a time. Initially you may want to indicate the number(s) eliminated as you present each clue.

)irections: Use each set of numbers and clues to name only one number that satisfies all clues.

CASE N1. NUMBERS: 2 5 8 12

CLUES:

1. I am less than 10.
2. I am even.
3. I am greater than 4.

My name is _____.

CASE N2. NUMBERS: 4 47 32 39

CLUES:

1. I have two digits.
2. The digit in the units place is odd.
3. I am less than 45.

My name is _____.

CASE N3. NUMBERS: 7,863 3,706 6,378 8,367

CLUES:

1. I do not have 0 in my tens place.
2. My hundred's digit is 3.
3. I am odd.

My name is _____.

CASE N4. NUMBERS: 542,098 245,098 425,098 452,908

CLUES:

1. I have 0 in my hundreds place.
2. I am greater than 300,000.
3. I have 9 in my tens place.
4. The digit in my ten-thousands place is 4. My name is _____.

Which clue was not helpful?

ESTIMATING MILLIONS

Objectives
Estimating
Using a calculator

Materials
Handout page and calculator for each pair or small group of students
Rulers

Activity
Students work cooperatively to solve problems

A. **Directions.** Estimate the measurement and circle the answer closest to your estimate. Use your calculator to find the answer rounded to the nearest whole number and compare the number to your estimate.

1. One million seconds are about _____.

   12 days 12 weeks 12 months

2. One million minutes are about _____.

   6 months 2 years 10 years

3. One million inches are about _____.

   1 mile 6 miles 16 miles

4. One million feet are about _____.

   50 miles 200 miles 1000 miles

B. **Directions.** Estimate the measurement. Then determine a better estimate by measuring and using your calculator.

1. How high is a stack of one million pennies?

2. How heavy is one million dollar bills?

Through class discussion help students determine a strategy for making good estimates. Make rulers available so that students can measure small quantities of pennies. Tell students that 20 one-dollar bills weigh about 7/10 of an ounce.

FIVE COME ALIVE!

Objective

Writing an equation using arithmetic operations.
Solving a problem using the guess and check strategy.

Materials

Deck of playing cards with face cards removed

Activity

Remove the face cards from an ordinary deck of cards (an Ace counts as 1). Draw five cards, call out the numbers, and place the cards side by side on the chalk tray. Draw another card (the target number), call out the number, and place it to the right of and separated from the other cards on the chalk tray. Set a time limit within which each student should attempt to write one or more equations that involve the arithmetic operations (addition, subtraction, multiplication, and division) in an expression that is equal to the target number. Stress the importance of correct order of operations and use of parentheses (when needed).

When the time has expired, call on several different students to come up and write an equation on the board or overhead projector. Check solutions carefully for correct order of operations, use of parentheses, and computation.

> Example. If the five numbers are 7, 1,2,5,4 and the target number is 5, one equation is (7 x 2 x 1) - (5 + 4) = 5. (Parentheses may be removed around factors since multiplication is performed prior to addition and subtraction.)

Reference

Schell, V. (1986). "Foxy Fives," *Activities From The Mathematics Teacher To Implement The Agenda For Action.* Reston, Va: National Council of Teachers of Mathematics.

Variations

1. Place several decks of cards in a math center and allow students who finish their work early to take a deck back to their desks, deal five cards and a target number, and write equations.

2. Allow groups of students to play the following game. The dealer gives each player five cards and turns up a card with the target number in the center. Players attempt to use their numbers to write an equation with the target number.

FUN WITH FACTORS

Objectives

Identifying factors of a number.
Using a calculator to arrive at a predetermined number.

Activity

Write game rules on a transparency or give each student a copy. Explain the rules to be certain that all students understand how to play the game. Separate students into pairs who are evenly matched with respect to mathematical ability and knowledge of factors and multiples.

> Rules: Hold the calculator so that your partner cannot see the numbers that you select. Enter a two-digit number and multiply it by one-digit numbers until you reach a five-digit display. Give the calculator to your partner, who will attempt to factor the number by dividing by one number at a time. Your partner scores one point for each division that leads to a whole number display. When a decimal number appears, your partner's turn is over, and he or she follows the rules for obtaining a five-digit number for your to factor. Take turns and play as many rounds as possible before time is up. Total the scores for the completed rounds to find the winner.

Set a specific time for students to play. Follow the activity with a written activity which requires students to factor multi-digit numbers using a calculator.

> Sample problems: Use your calculator to write each number as a product of prime factors.
>
> | | | | |
> |---|---|---|---|
> | 1. 300 | 3. 630 | 5. 1,275 | 7. 12,285 |
> | 2. 350 | 4. 560 | 6. 1,475 | 8. 30,800 |

After students have played on several different occasions, discuss a strategy for limiting the score of an opponent. What kind of starting number should you choose? What kind of one-digit factors should you enter? If you are the player who is attempting to factor the number, should you use the largest or smallest number that you recognize as a factor each time that you divide?

Reference

Morris, J. (1981). *How to Develop Problem Solving Using a Calculator.* Reston, Va: National Council of Teachers of Mathematics.

GH DRAW

)jective

Creating the greatest number, given a certain number of digits (six, seven, eight, or nine).

ıterials

A set of cards containing at least two each of the numerals 0-9 for each player in a group.

:tivity

Explain the rules orally or write them on the board. (The rules below are written for numerals with six digits.) Ask students if they have questions about how to play the game. Separate students into pairs or groups of three players.

Rules.

1. One player shuffles the deck and deals six cards to each player.
2. Each player makes the largest number possible with the cards.
3. The player with the largest number says, "I have the largest number. My number is _____."
4. If the player with the largest number reads it aloud correctly, he/she gains one point.
5. The next dealer collects all cards, shuffles them, and deals six to each player.
6. The game continues until one player has a certain number of points.

ıriation

Each player has a card with a decimal point. Players must make the greatest number with one digit representing tenths (or two digits representing hundredths).

ɜference

Harrison, M. and Harrison, B. (1966). "Developing Numeration Concepts and Skills." *Arithmetic Teacher*, 33 (6), 18-21, 60.

HOW BIG IS A THOUSAND? HOW MUCH IS TEN DOLLARS?

Objective

Grouping a large number of objects by tens, hundreds and thousands
Writing the numeral for the number of objects
Writing the amount of money if each object has a value of one penny

Materials

Large number of small objects in a jar
Plastic zipper bags of three sizes and a small paper cup (or paper cups of four sizes)

Activity

Place a large number of small objects (pennies, washers, lima beans, peas) in a jar so that students can see that the container is full. Ask them to guess how many objects are in the jar. Write guesses on a transparency or the board. Ask students to check that you wrote the numeral correctly for each guess. Give each student a subset of the objects to count by grouping by tens. Ask students to find partners and pool their sets of objects, grouping each set of ten tens to make a hundred. Have each pair pool their set with another pair, and so forth. When all groupings of thousands, hundreds, and tens have been made, collect each set of 1000 objects and place it in large a zipper bag, place each set of 100 objects in a smaller zipper bag, each set of 10 objects in the smallest size of zipper bag, and the remaining pennies in a small paper cup. Count the number of large bags, the next size bags, the small bags, and the number of objects in the paper cup. Write the numeral representing the number of objects on the board.

Ask students to suppose that each object is worth one cent. What would be the value of the entire collection? Help students understand that we could exchange the objects for ten dollar bills, one dollar bills, dimes, and pennies and write the amount of money on a chart. For example, 2 large bags, 8 smaller bags, 1 smallest bag and 5 objects could be represented in the following way:

ten dollar bills	one dollar bills	dimes	pennies
2	8	1	5

Introduce a decimal point as a device to separate the bills from the coins in the chart. The number represented in the chart could then be written as 28.15, or $28.15.

MAKE MY NUMBER

Objective

Identifying place value of digits in whole numbers
Writing whole numbers up to 100,000

Materials

Several sets of large cards with numerals 0-9
List of some numbers between 1,000 and 100,000 in which no digit is repeated

Activity

Separate class into teams with ten students in each team. Have other students act as readers and judges. Give each team a set of numeral cards. Team captains distribute a card to each team member. Members of each team form a line facing the other team, leaving the chalk tray in view of the judges. The teacher or a designated student reads the number twice before members of the teams move. After the second time the reader says "begin," and members of the teams with the digits in the numeral move to the chalk tray and arrange the numerals to form the number. (Suitable penalties should be specified for moving before "begin.") The team that first forms the numeral correctly is awarded a given number of points. The first team with a specified number of points is the winner.

Variations

1. Each team is given a decimal point as well as a set of digits. Decimal numbers with a certain number of places are read instead of whole numbers.

2. Teams are made up of pairs of students. Two or three teams complete in each round. Line up numerals in random order on chalk tray, one set for each team . Contestants stand behind a line or sit in chairs facing the sets of numerals. Each number is read twice before students move toward the board and arrange the digits to form the correct numeral.

PARTY GUESTS

Directions: Read the problem carefully. Do you understand the problem?
Fill in the blanks to solve the problem and to discover something about the numbers in the table.

Problem: Tina is having a birthday party. When the doorbell rings the first time, Tina welcomes one guest. On the next ring, she greets two more guests than arrived on the first ring. On each ring of the doorbell, Tina finds a group that has two more people than the group that came before. How many guests arrive on the 10th ring? How many guests does Tina have in all after the 10th ring?

PARTY GUESTS

(1) Ring Number	(2) Number of Guests Arriving	(3) Total Number of Guests
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____
6	_____	_____
7	_____	_____
8	_____	_____
9	_____	_____
10	_____	_____

1. What kind of numbers are in column (2)? _____
2. How many guests came on the 3rd ring? _____
   5th ring? _____ 8th ring? _____ 10th ring? _____
3. What kind of numbers are in column (3)? _____
4. How many guests were at the party after the 4th ring? _____
   6th ring? _____ 7th ring? _____ 10th ring? _____

Practice with Divisibility

Instructions:

Answer each question and check your results with a calculator. Some questions may have more than one possible answer. Try to find all possible answers. Number 1 has been worked for you.

1. What digit(s) can be placed in the blank so that the number 28___45 is divisible by 9 ?
   (Answer: 8)

2. What digit(s) can be placed in the blank so that the number 35 ___ 2 is divisible by 4 ?

3. What digit(s) can be placed in the blank so that the number 3 ___ 333 is divisible by 9 ?

4. What digits can be placed in the blanks so that the number 73___ ___ is divisible by 4 and 9 ?

5. What digits can be placed in the blank so that the number 125___ ___ is divisible by 4 and 9 ?

6. What digits can be placed in the blank so that the number 6___5___6 is divisible by 4 and 9 ?

7. If a number is divisible by 4 and 9, it must also be divisible by 36.
   How many numbers less than 1000 are divisible by 4 and 9 ?
   (Hint: Think how many multiples of 36 are there that are less than 1000)

A Prime Formula

For centuries mathematicians have tried to develop formulas that would generate prime numbers. The formula below seems to be a successful one for generating primes.

$$n^2 + n + 41$$

Try it for a few cases by letting "n" be the numbers 1, 2, 3, 4,.....
Use your calculator for computations.

Case	$n^2 + n + 41$	Prime?
n = 1	43	yes
n = 2	47	yes
n = 3	53	yes
n = 4	____	____
n = 5	____	____
n = 6	____	____
n = 7	____	____
n = 8	____	____
n = 9	____	____
n = 10	____	____

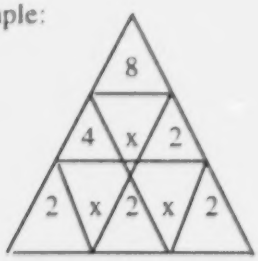
Is each result a prime number? _____

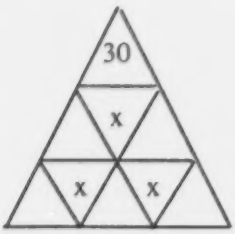
Can you think of a number that would not yield a prime number?
(Try the cases n = 40 and n = 41. Use your calculator to see if the results are prime.)

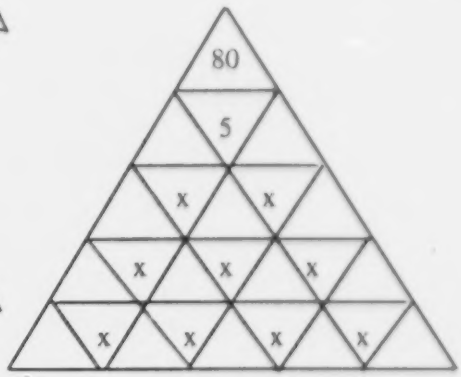
Prime Triangles

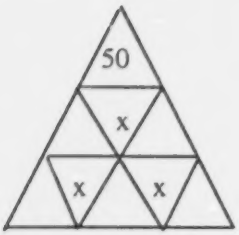
If a number is composite it can be factored uniquely into prime factors. This property is called the Fundamental Theorem of Arithmetic. One way to factor composite numbers is to use a factor triangle. Start with the number in the top angle of the triangle. Factor it into the product of two numbers. Continue factoring any composite numbers that appear as factors until you reach the bottom row. Every number in the bottom row should be a prime number. Check yourself by multiplying the numbers in the bottom row together to see if the product is the number with which you started.

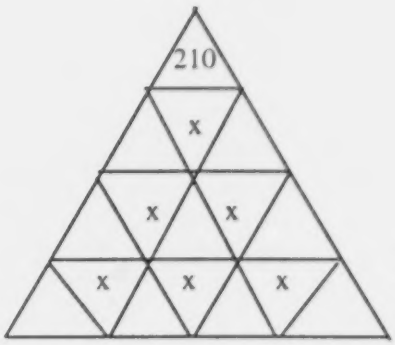
Example:

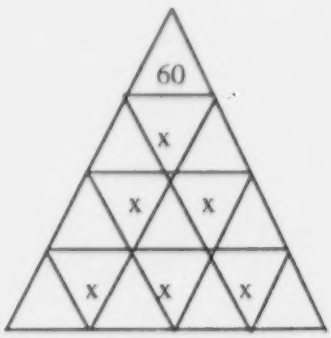












PROPERTIES OF OPERATIONS

UNIVERSE _____

Directions. If the operation has the property write "yes" in the appropriate place on the matrix. If the operation does not have the property write "no" and write a counter-example to justify your conclusion.

Property	Operation			
	addition	subtraction	multiplication	division
closure				
commutative				
associative				
identity element				
inverse element				

Directions. Describe other properties of operations using proper mathematical symbols.

1. distributive (_____ over _____):

2. properties of zero:

3. other properties:

SECRET NUMBER

Objective

Using properties of numbers and number relations to name an unknown number.

Activity

Divide the group into two teams. Tell the students that they are to try to name a secret number that you have written on a piece of paper. They are to determine the number by asking questions that you can answer "yes" or "no." Give some examples of appropriate questions, such as

Is it greater than _____?
Is it less than _____?
Is it between _____ and _____?
Does it have _____ digits (places)?
Is its tens digit (place) _____?
Is it a prime number?
Is it positive?

On the other hand, the question "How many digits does it have?" is not acceptable. The first team to name the number written on the paper sends a member up to select the next number and answer questions about it.

Additional rules: (1) Each team must establish an order in which players will ask questions. If anyone responds out of order, the team loses a turn. (2) Every player on a team must have a turn in the questioning order. (3) If a player asks a question that cannot be answered "yes" or "no," the team loses a turn. (4) If a player asks a question that does not gain new information, the team is not allowed to substitute another question.

Each time that a new round begins, the person who selects the secret number should give some information about the set from which the number was chosen. For example,

It is a whole number less than 100.
It is an integer between -50 and +50.
It is a fraction in lowest terms between $\frac{1}{2}$ and $\frac{3}{4}$.
It is a decimal number less than 1 with two digits.

Numbers that are chosen should be reasonable with respect to the time needed to name them; therefore, when a student selects a secret number, he/she should tell you the number and the initial clues so that you can judge whether the round can be completed in a reasonable length of time.

WHAT NUMBER AM I?
Sample Problems

Problem	Solution
I am between 20 and 50. I am a multiple of 5. I am a multiple of 7. Who am I? _____	35
I am a factor of 24. I am even. I am between a 10 and 20. Who am I? _____	12
I am a factor of 100. I am a multiple of 5. I am not a multiple of 2. Who am I? _____	25
I am a multiple of 3. I am not a multiple of 6. I have two digits. I am less than 20. Who am I? _____	15
I am a factor of 36. I am not a prime number. I am even. I am between 12 and 30. Who am I? _____	18
I am less than 30. My ones digit is twice my tens digit. My digits add up to an even number. Who am I? _____	24
I am a perfect square. I have two digits. The sum of my digits is also a perfect square. I am less than 50. Who am I? _____	36
I am an odd multiple of 9. The product of my two digits is also a multiple of 9. I am greater than 50 and less than 90. Who am I? _____	63
I am a perfect square with two digits. The sum of my digits is my square root. Who am I? _____	81

APPENDIX C

Physics 460--Daily Schedule

Session 1--Systems of Measurement

Objectives:

1. Define and give examples of fundamental and derived units of measure.
2. Identify the seven fundamental quantities of measure and state their SI units.
3. Discuss imperatives for science education: science imperatives, societal imperatives, childhood imperatives.

Class activities:

Discuss syllabus.

3. Preview science education imperatives. Overview the state of elementary science education. Use NAEP data.

2. Discuss measurement as an essential tool for science and a mathematical skill. Divide students into groups. Brainstorm a list of as many words as they can think of related to measurement. Further subdivide the list into quantities, units, measuring instruments and other. Discuss the difference between a quantity of measure and a unit of measure. Have them then attempt to match quantities and units of measure, supplying any missing quantities or units.

1. Explain the difference between a fundamental and a derived quantity of measure(Use length (fundamental), area and volume as examples). Have students attempt to identify the fundamental quantities from their lists.

2. Use "Systems of Measurement" handout (Appendix D) to discuss the fundamental quantities and units of measure.
Emphasize that fundamental quantities(eg, length) have both fundamental(meter) and derived(centimeter or mile) units. Derived units are related to fundamental units by a conversion factor. Derived quantities are related to fundamental ones by a defining formula. Defined quantities have units which may involve multiplied or divided units.

Math connection: Integral

Teaching Science: see above

Homework: Gega, Chapter 1. Chapter 4, 71-97. Bennett, Measurement, pp. 375-395.
Build a balance for Session 4. TOPS Metric Measuring, "Soda Can Balance," "Gram Quarters," "Gram Grids"

Session 2--Problem Solving and Process Skills (Together)

Objectives:

1. Become acquainted with taxonomies for describing problem solving and process skills.
2. Identify how the Georgia QCC treats process skills, and the process skill taxonomy used there.
3. Describe the relationship between problem solving and process skills
4. Use problem solving strategies and process skills

Class Activities:

1. Problem solving strategies (handout, Appendix D)
2. Problem solving applications.
3. Process skills (Handout, Appendix D)
4. Brainstorming Activity --Measuring Wheel(Appendix D)
5. Math skills sequencing chart (Appendix D)

Math Connection: Integral

Teaching Science: Integral

Homework: Build a measuring wheel for session 3.

Physics 460--Daily Schedule

Session 3--Metric System, Length, Area

Objectives:

1. Record a measurement with an appropriate degree of precision--i.e. all measurements will contain one and only one estimated digit.
2. Measure length using non-standard objects, rulers or calipers.
3. Use a conversion factor to convert between units of length measure.
4. Convert within the metric system from milli- to kilo-
5. Identify perimeter as a length measurement.
6. Describe area. Find area by covering, drawing on grid paper, using a geoboard, and multiplying.
7. Identify the progression in measuring length and area and suggest appropriate measuring instruments for various levels.
8. Estimate lengths of moderate size objects visually. Develop techniques for estimating lengths that are too large or small for standard measuring instruments.

Class activities: (Activities from TOPS Metric Measuring and More Metrics, and AIMS

1. Provide metric measuring tapes and ask students to identify a body part corresponding to a meter, decimeter, centimeter and millimeter.
2. Discuss metric conversions. TOPS "Metric Stairs" and additional problems with answers.
3. Display a variety of objects. Estimate length and discuss which metric length unit is appropriate. Discuss when to use tapes, calipers, wheels. Demonstrate use of standard and non-standard length measuring objects, including centicubes, base blocks and unifix cubes.
4. Use a ruler marked in cm. and one marked in mm. to make a measurement. Describe how to estimate the space between marks. Use TOPS, More Metrics, "The Last Digit" and "Line Measuring".
5. Demonstrate finding the area of objects using TOPS, Metric Measuring, "Squared Dimensions". Demonstrate finding area of regular and irregular objects using grid paper. Have students make rectangles of various areas on geoboards.
6. Use sequencing chart to identify grade level placement of length, perimeter, and area. Find areas of triangles, trapezoids and circles using counting squares and formulas. Emphasize making appropriate measures.
7. Introduce significant figure rules for multiplication and division. Compare answers obtained from calculation and rounded using rules with answers obtained by drawing on grid paper and estimating.
8. To demonstrate one area application, set up AIMS evaporation activity.
9. Collect measuring wheels.

Discuss AIMS and TOPS curriculum material

Math connection: Integral, use of calculators and geoboards

Teaching science: Process skills, developmental appropriateness, using checklists and scoring rubrics, AIMS curriculum materials

Homework: More Metrics, "Certain and Uncertain", Metric Conversion Practice Problems (Appendix D), Read Section 8.2, 8.3 in Bennett. Problems 2,3,4,5,6,8, for section 2.

Physics 460--Daily Schedule

Session 4--Volume and Mass

Objectives:

1. Use a ruler or water displacement to measure and calculate volume.
2. From measured quantities, calculate area, volume, perimeter
3. Construct a balance.
4. Use various kinds of balances to measure mass.
5. State the equivalence between volume (cm^3) and liquid capacity (ml).

Class activities:

1. Check evaporation activity, answer questions on problems
2. Show objects of various masses and volumes. Ask which is larger. Discuss the confusion in the term "larger", and describe volume and mass as indicators of size.
3. TOPS Metric Measuring, "Cubed Dimensions" and "Length, Area, Volume" in small groups. Continue emphasizing proper recording of data and rounding of calculated answers. Remind students that volume is a derived quantity. Collect 1 "Cubed Dimensions" per group for participation grade.
4. Explain the relationship between volume and liquid capacity, using centicubes. Demonstrate how to read a graduated cylinder. Demonstrate how to use water displacement to find the volume of irregularly shaped objects.
5. Introduce significant figure rules for addition and subtraction.
6. Describe mass as a fundamental quantity. Pass around kilograms to introduce fundamental units.
7. In groups, find the mass of various small objects on student-made balances.
8. Demonstrate the use of various kinds of balances. Have learning centers available for extra practice, as students have varying experience with measuring implements.
9. Discuss guidelines for mass and volume measuring equipment for various age/grade levels. Introduce the difference between a balance and a scale.
10. Grade balances.

Math connections: Significant figures, place value

Teaching science: Measuring equipment.

Homework: Bennett, problems 2,3,4,8,9,24, section 3.

Physics 460--Daily Schedule

Session 5: Organization of Mathematics and Science Curriculum

Objectives:

1. Identify the NCTM Standards as a driving force in mathematics education reform.
2. Identify the Science Standards and the 2061 Benchmarks as driving forces in science education reform.
3. Examine the interaction between science and mathematics.
4. Compare the Georgia QCC to the recommendations for curriculum reform.
5. Identify journals (Arithmetic Teacher, Mathematics Teacher, Science and Children, Science Scope, and School Science and Mathematics) and curriculum materials which are sources of activities consistent with contemporary recommendations for teaching science and mathematics.

Class Activities:

1. Check on evaporation activity.
2. NCTM video, "Reaching Up"
3. Executive summary, NCTM standards
4. Relationship of science standards development to math standards development.
5. Summary, science standards.
6. Introduction to QCC: what is it, when and how was it developed.
7. Introduction to resource unit assignment. Note differences: math is many topics, one grade level; science is same topic, multiple grade levels. See Appendix for directions.
8. Display sources for finding activities and describe where and how to find them.

Math Connection: Standards, Periodicals

Teaching Science: Professional associations and journals, sources of teaching resources. Reading material introduces constructivism and conceptual change teaching.

Homework: Gega, Appendix A and B. Graph results from evaporation activity and summarize. Gega, Chapter 2, pp. 41-49, "Children's concepts and misconceptions, and constructivist theory," read. Instructional Strategies handout, read.

Physics 460--Daily Schedule

Session 6--Density, Time, Temperature

Objectives:

1. Differentiate between intrinsic and extrinsic properties of matter.
2. Identify density as an intrinsic property of matter and use the formula D = M/V to calculate it.
3. Given two objects of similar mass or volume or which are capable of being floated, compare their densities. Calculate density.
4. State the density of water and compare it to that of metals and gasses. Describe the unusual density of water in the liquid and solid phases.
5. Relate sinking and floating behavior to density rather than mass or volume.
6. Use a thermometer to measure temperature.
7. Explain why density may change as temperature changes.
8. Use various devices to measure time.
9. Explain the day and night cycle, time zones, and the equinoxes based on earth's rotational patterns. Explain why summer is warmer than winter.
10. Explain the concepts of constructivism, schema, assimilation, accommodations and misconceptions, and apply them to learning about density and the rotation of the earth.

Class Activities:

Answer questions on volume problems. Discuss evaporation conclusions.

*2, 3, 10. Show an aquarium containing a variety of diet and regular sodas. Ask for observations. (Diet float, regular sink). Ask for predictions about floating and sinking with a grape and a cherry tomato. Show a potato, sink it, ask if a small cut off sliver will float. Repeat with bell pepper.

*3, 10. Ask students to prepare list of what they know about sinking and floating and what questions they have. Have them complete the sentence, "Objects float because....."

*2. Discuss student answers. Clarify terms mass, volume and density. Provide density formula. In groups let students measure mass, volume, density of various objects and observe sinking, floating behavior. (carrot, nut & bolt, styrofoam ball, Karo syrup, cooking oil)

*4. Use overflow cup to demonstrate that mass of water displaced equals mass of floating object. Relate to density of water. Compare densities of water and ice and discuss significance.

*10. Discuss student answers to #3 now. Explain constructivism, schema, assimilation, accommodation in this context. Use modeling clay in a ball and as a boat and ask for student explanations of sinking and floating.

*1,2,3. Have each group of students find the mass, volume and density of a different volume of cooking oil. Discuss that mass and volume differ, but density is the same for all samples. Do the same for modeling clay. Introduce the terms "intrinsic" or "characteristic" property for density, as one that can be used to identify a substance. Mass and volume are "extrinsic". Emphasize significant figure use.

8,1. Show a variety of thermometers. Have students read, to appropriate precision. Discuss alcohol vs. mercury. Discuss F, C and K scales including concept of absolute zero. Emphasize not teaching K-8 students to convert--just use both. Is temperature an intrinsic or extrinsic property?

7. Use ball and ring demonstration to show expansion on heating. Ask if mass changes, if volume changes, if density changes, and how? Expansion on heating is common and used in many devices. Show bore in broken thermometer, to demonstrate how expansion produces reading. Explain not shaking down scientific thermometers and not removing to read.

8. Show time measuring devices for short time intervals: Stopwatch, clock, egg timer, pendulum. Review using conversion factors. This is appropriate conversion.

10. Discuss celestial objects as time measurers. Assign mini learning center setup

Math connection: Integral

Teaching Science: Constructivism, learning centers

Homework: Gega, pp. 645-648 (Motion of earth, time and seasons) and 135-146 (learning centers) read. Assign investigations: The Way the Earth Rotates, A Shadow Clock, Midday Where You Live, How Warm is Slanted Sunshine to be performed prior to and set up as mini learning centers with record sheets by next class period. Provide handout of this lesson plan. Have students identify phases of the learning cycle with the starred items on a lesson plan, and write 2-3 paragraphs explaining how the starred portion of the lesson plan were sequenced in accordance with the learning cycle.

Physics 460--Daily Schedule

Session 8--Describing Motion

Objectives:

1. Identify force, motion, machines curricular components in Georgia QCC and examine rationale for grade level placement.
2. Describe the concept "frame of reference"
3. Describe the position and motion of an object using internal and external frames of reference.
4. Identify a map or graph as a frame of reference.
5. Distinguish between vectors and scalars
6. Describe the displacement of an object. Find the resultant of two displacements.
7. Use or draw concept maps to clarify schema.

Class Activities:

Explain use and location of mini learning cycle activities. Discuss short essays. Have students write phases on file card and assign today's activities to phases.

1. Examine copies of "Heat & Energy" and "Machine and Force" QCC.

2,3. SCIS Relative Position and Motion. Use the Homer & J.P. stories to introduce the idea of frame of reference. In groups, use "Mr. O" to describe location of objects from two different internal frames of reference, then from an external frame of reference. Point out Mr. O's asymmetry.

4. Discuss the terms that had to be used to describe locations: near, far, left, right, above, etc. Introduce concepts: magnitude, directions. Discuss how to quantify magnitude and direction. Place Mr. O's on large floor maps. Describe positions with respect to grids and external objects.

5. Define vectors, scalars.

6. Use geoboards to construct various displacements. Point out results of displacements.

1. Relate use of internal/external frames of reference to switch from egocentrism.

7. Explain concept map. Discuss SCIS and early elementary curriculum reform projects.

Collect learning cycle analysis.

Math connections: symmetry, graphs, vectors

Teaching science: SCIS materials

Homework: Motion handout from Teaching Physical Science, "The Magnitude of Motion" from Methods of Motion, read. Do mini learning center activities. Turn in record sheets from two besides your own for daily grades.

Physics 460--Daily Schedule

Session 9--Velocity and Acceleration
Objectives:

1. Measure the displacement of a moving object
2. Employ notation to represent displacement and intervals of time
3. Calculate the speed of a moving object
4. Determine whether or not an object is moving at constant speed.
5. Explain the differences between speed, velocity and acceleration.
6. Identify forces that can produce an acceleration.
7. Give an example of an operational definition.
8. Use formulas to define velocity, acceleration and force and correct units for each.

Class Activities:

1, 2, 3. Show *Eureka!* Program 5. Demonstrate Methods of Motion(MOM): Activity 10 (Determining the Speed of a Toy Car).
4, 1. Demonstrate Activity 11, MOM (Is the Speed of a Toy Car Constant).
5, 6, 1. Demonstrate Activity 12, MOM (Determining the Acceleration of a Toy Car).
Refer to concept map for relationship between activities.
Discuss NSTA as a source of curriculum materials

Math Connection: Independent and dependent variables, making charts and tables

Teaching Science: Curriculum materials produced or sold by NSTA

Homework: Reading 8, MOM (An Intuitive Approach to Defining Acceleration), Reading 9, MOM (Algebraic Representation of Acceleration). Read.

Physics 460--Daily Schedule

Session 10--Interactions of Force, Mass and Acceleration

Objectives:

1. State an algebraic definition of momentum.
2. Demonstrate the relationship between momentum and mass for objects traveling at the same speed.
3. State and demonstrate Newton's second law of motion.
4. State Newton's third law of motion in two ways: in terms of action and reaction pairs and in terms of opposing forces.
5. Identify forces that prevent most objects near Earth from traveling in a straight line at a constant speed.

Class activities:

1, 3. Show *Eureka!* Segment 4.
2. Demonstrate Activity 17, MOM (A Marble Race: Does the Mass of the Marbles Affect the Results?)
2. Demonstrate Activity 18, MOM (Marble Momentum--Mass Versus "Bashing Power).
4. Demonstrate Activity 20, MOM (Kodak Cannons: Investigating the Motions of Action-Reaction Pairs)
5. Perform Activity 24, MOM (How Do Hidden Forces Affect Falling Objects)

Discuss management strategies for a class with these activities.
Refer to concept map for relationship between concepts.

Math Connection: Problem Solving: finding a pattern

Teaching Science: Managing Hands-On Activities

Homework: Activity Writeup 17, 18, 24 (graded). Readings 10-13, MOM (Momentum, Newton's Second Law of Motion, The Third Law of Motion, Can Objects Break the Laws of Motion). Gega, pp. 126-133 (Managing Hands-on Activities), read.

Physics 460--Daily Schedule

Session 11--Gravity

Objectives:

1. Identify gravity as a force.
2. Describe projectile motion.
3. Locate and define the center of gravity of an object.
4. Demonstrate how the location of an object's center of gravity affects the way that object sits, stands or moves.
5. Distinguish between mass and weight.

Class Activities:

1. Ask students what makes objects fall. Ask for predictions about relative drop rates of light and heavy objects. Show *Eureka!* Segment 8, Gravity. Discuss why we asked about student prior conceptions.
2. Observe carefully motion of ball dropped and thrown upward for acceleration. Ask why ball does not move sideways (no external force). Observe motion of projectile shot from dart gun. Ask about external forces in vertical and horizontal directions. Ask about vertical and horizontal accelerations.
5. Intuitive definition of gravity: a pull on an object. Gravity is really an attractive force between two objects, like magnetic attraction that depends on sizes of objects and distance between them. Explain difference between mass and weight. Show how a scale is different from a balance.
2. Activity 3, Evidence of Energy (EOE), Airmail Bowling Balls.
3. Activity 26, EOE, Discovering Your Personal Center of Gravity.
4. Activity 27, EOE, Cynthia's Hanging
4. Activity 28, EOE, Uphill Roller and Balancing Pencil. Discuss as discrepant events.

Refer to concept map for relationship between concepts.

Math Connection: Data analysis, using formulas

Teaching Science: Discrepant events and their usefulness in the engagement and exploration phases of the learning cycle.

Homework: EOE, Readings 2, 3, 4.

Physics 460--Daily Schedule

Session 10--Machines

Objectives:

1. Describe how a simple machine helps do work. Define and describe the units of work.
2. Identify the six simple machines, and the two on which they are based.
3. Define and calculate mechanical advantage.
4. Assemble a complex machine by combining several simple machines.

Class Activities.

1. Show *Eureka!* Segments 8, 11 and 12. Discuss inclined plane and lever as two most basic simple machines.
2,3. Demonstrate each of other simple machines. Describe whether machine reduces effort or distance or changes direction of force.
4. In groups, perform Activity 18, Evidence of Energy (EOE), "Testing a Paper Clip Pulley System".
5. Show transparency of "Porthole Closer, Blanket Puller-Upper" (EOE, p. 89). Discuss student machine construction assignment.

Math Connection: Constants, Variables.

Teaching Science: Laboratory Activities

Homework: EOE Reading 5, "How Hard Are You Working? What Are You Working Against?"

Physics 460--Daily Schedule

Session 12 --Matter

Objectives

1. Identify age/grade appropriate concepts about matter
2. Distinguish between pure substances (elements and compounds) and mixtures (solutions, colloids, suspensions, gross mixtures).
3. Use the terms atom and molecule correctly.
4. Describe evidence for the existence of atoms.
5. Identify important regions of the periodic table, and representative important elements.
6. Describe the importance of chemical formulas and their appropriate use in grades K-6.

Class activities:

1. Discuss how one constructs meaning about an idea. Describe the historical development of our knowledge about elements and atoms (Some elements have been known since antiquity--which ones are mentioned in the Bible?). Others were not discovered until after the discovery of current electricity (1800) because you can't set them free from compounds without it. Others are still being discovered.

When and how did someone discover that a gas was something? (Torricelli, who invented the barometer, was Galileo's assistant--1600.) Gases could not be weighed effectively until there were good analytical balances. Greeks had the idea of atoms in about 400, but John Dalton (1800) set out first modern atomic theory. It was based on weight relationships in chemical reactions, and requires proportional reasoning to follow the argument. Understanding of subatomic particles was about 1900. A good rule of thumb is, the later it was discovered, the more technological and/or indirect the evidence is and the later it needs to be taught in school.

Gist of the matter is: concepts like atoms, molecules and elements are fine on a qualitative level. Leave atomic theory alone. New science education studies, 2061 Benchmarks and National Science Standards, recommend only emphasis on observable and measurable properties which can be used to separate materials, and on the gaseous, liquid and solid phase and phase transitions in grades K-4. In grades 5-8, emphasis remains on properties, phase transitions and conservation of mass. Gas law behavior (qualitative) is appropriate. The particulate model of matter is used to describe the conservation laws, chemical change and the properties of solids, liquids and gases. Atomic structure is deferred to grades 9-12.

2. Use concept map to illustrate classification of matter. Explain what definite and variable composition mean. Explain the importance of characteristic properties in determining whether something is pure. Have students construct a temperature vs. time graph while boiling various substances: pure water, sugar water, salt water, t-butyl alcohol. Observe the difference between the behavior of pure substances and mixtures.

3,6. To explain the difference between atoms and molecules, display a variety of items as they are packaged: an orange, a dozen eggs, a pair of shoelaces, a card of snaps, a bottle of soda. Write formulae O, E_{12}, Sl_2, $T_{12}B_{12}$, So. Each of these represents a molecule of that substance.

Molecule definition: Smallest chemical species of a substance that is capable of stable, independent existence. (My analogy: it's how you buy them). Atom: smallest particle of an element that can exist either alone or in combination with other atoms of the same or other elements. (Atom examples: one orange, one egg, one shoelace, one top snap). Molecules can have one atom, more than one identical atom (molecules of

elements), or more than one kind of atom (molecules of compounds). You have to learn how atoms are packaged. (Use periodic table--Metals are monatomic, Hydrogen, oxygen, nitrogen, and halogens are diatomic. Other nonmetals may be polyatomic, although noble gases are monatomic. Explain symbolism in chemical formulas. Understanding notation is appropriate in grades 4-8. Generating formulas is not.

4. Evidence for the existence of atoms: Law of conservation of matter. Perform a variety of reactions inside Ziploc bags. Demonstrate that weight remains the same, but properties differ. Chemical change has to be a rearrangement of atoms. Other laws (constant composition, multiple proportions) also rely on weight relationships, but are too complicated for K-8.

5. Display periodic table. Point out metals, non-metals, noble gases. Note location and names of elements which children may know. (Hydrogen, helium, oxygen, nitrogen, phosphorus, sulfur, carbon, chlorine, iron, copper, silver, gold, tin, lead, zinc, arsenic) Provide samples, if possible. Discuss the fact that we are familiar with compounds of group I and II--the elements are too reactive to hang around loose. Most important distinction is metal/non metal.

Math Connection: limited

Teaching Science: Standards and Benchmarks and their ability to inform what we do.

Homework: Gega, Ch 9,pp. 241-250. Read.

Physics 460--Daily Schedule

Session 13 --Heat & Temperature

Objectives:

1. Distinguish between heat and temperature, and their units and measuring devices.
2. Identify melting point, boiling point and specific heat as intrinsic properties of matter.
3. Use the kinetic theory of matter to explain the role of heat and molecular motion during temperature changes and phase changes.
4. Demonstrate the methods of heat transfer: convection, conduction and radiation.
5. Describe how water is used as a standard for specific heat, why its high heat capacity is important, and how its expansion/contraction behavior is unusual.
6. Define heat as a form of energy. Define units for energy.

Class activities

Establish indirect evidence for the existence of molecular motion and the relationship between heat and molecular motion:

a) Drop one drop of food coloring into the top of a large container of hot and cold water. Observe and explain color dispersion.

b) Place spoons made of various material: silver, stainless steel and plastic in a container of hot water. Ask students to respond when they feel the spoon get hot. Ask how the spoon got hot.

1,5. Display a large and small container of hot water (at the same temperature) with a thermometer in each. Ask what is the same about them. Ask which will get cold first. Ask what a thermometer measures and in what units. Ask how to measure heat, and in what units. Display calorimeter. Define heat as a form of energy;joules or calories are acceptable units. Place 3 100 ml beakers on the same hot plate with a thermometer in each. Put 25 ml. water in one, 50 in another, 75 in 3rd. Read temperature, heat 3 minutes, read temperature again. All get the same amount of heat, but show different temperature rises. Calculate amount of heat gained (Sp ht*temp change*mass water). Demonstrate that, within the accuracy of measurement (2 sig fig) heat gains are similar. Definitions: Heat--<u>total kinetic energy</u> of all the molecules in a material. Temperature--<u>average kinetic energy</u> of the molecules of a material. Temperature is a fundamental quantity.

3. Kinetic molecular theory: See activity (Appendix D), to act out kinetic molecular theory as it applies to phase and temperature changes.

4. Heat transfer also involves motion. Demonstrate conduction (Gega, p. 263, How Does Heat Travel in an Iron Rod?), Convection (Gega, p. 265, How do Warm and Cold Water Form a Current?, Where Does Warmed Air Go?), Radiation (Gega, p. 270, Where is it Hottest Around a Lighted Lamp?). Students can act out conduction by standing in a line, shoulder to shoulder, and having the first people vibrate and watching the vibration travel down the line. Point out that conduction is primarily a solid phenomena, Convection is liquid and gas, and radiation does not involve the medium except in determining the speed at which it travels. Introduce the term "insulator" to describe poor heat conductor.

5. Melt several objects: butter, paraffin, t-butyl alcohol, ice. Observe the sinking/floating behavior. Contrast with water and ice. Discuss why that matters (insulation in winter, animal life).

Math connection: Graphing, seeing patterns

Homework: <u>EOE</u>, Reading 6, Forms of Energy

BEST COPY AVAILABLE

Physics 460--Daily Schedule

Session 14 --Magnets and Magnetic Fields

Objectives:

1. Recognize that only a few metals like iron, cobalt, nickel and their derivatives are noticeably magnetic, while most other metals and non metals are not
2. Label the north and south poles on unmarked magnets by using the earths magnetic field as a reference
3. Map the shape of the magnetic field surrounding a magnet
4. Appreciate that a magnetic field can pass through solid objects as long as they are not magnetic.
5. Develop a simple interpretive model to explain differences between strong magnets, weak magnets, magnetic materials and nonmagnetic materials.
6. Identify magnetic attraction as a force, similar to gravity.

Class Activities

From TOPS learning systems: Magnets (Number in parentheses is activity number)

1,6. Is it magnetic. (1) Discuss reason for using Venn diagram and importance of including copper, aluminum and other metals that are not magnetic, in light of common misconception that metals are attracted to a magnet.

2. Name that pole. (2) Discuss common picture of magnets shown in textbooks (Gega p 328) and the fact that poles are usually drawn on the end of bars, when they can, in fact be on any end or side. Location must be determined by using something to visualize and orient the field.

3. A. Use iron filings encased in a glass petri dish (taped edges so the filings don't go everywhere) to demonstrate the three dimensional nature of a magnetic field and what the field looks like at the poles. If desired, allow students to examine plastic bags filled with a mixture of sand and filings and use a magnet to separate them. Also, an envelope of Instant Cream of Wheat can be emptied into a zipper bag, and a strong magnet used to separate out the food grade iron filings. This is best visible over a sheet of white paper.

3. B. Map a magnetic field (11) Also demonstrate that a pin or nail is magnetized either by leaving it in contact with another magnet or by stroking it always in the same direction. (Gega, p. 323)

4. Up in the air. Discuss how magnetic (and gravitational) fields penetrate solids and liquids. Remind students that they have observed penetration through glass (petri dishes) and wood (metal supports under desk tops)

5. Magnetic models (7). Explain to students that magnetic domains arise from unpaired spinning electrons in atoms, and show location of ferromagnetic materials in periodic table. Explain that there are many more weakly magnetic (paramagnetic) materials, but that ferromagnetism results from the combination of lots of like spin, unpaired, and properly spaced electrons, and only these elements have those properties. Relate this to 3B above.

Teaching Science: Give students copy of the QCC for electricity & magnetism. Point out that it is very general, and that magnetism last appears at grade 3, and only shows up again in grade 9. There are magnetism topics that are appropriate at grades 5 or 6 and probably need to be taught at that time.

Math Connection

Activity 1 uses Venn diagrams in classification

Homework assignment involves graphing how the strength varies with increasing distance from the magnet.

Homework Assignment

TOPS: Magnets Activity 8, Strength of a Magnet (graded)

Gega: Chapter 11, Magnetic Interactions. Read.

Physics 460--Daily Schedule

Session 15 -Magnets and Compasses

Objectives:

1. Relate the strength of magnetic attraction to the distance from the magnet.
2. Describe the parts of a compass and how it works.
3. Explain the difference between geographic and magnetic north, and describe the pole of a magnet labeled "north" as a north seeking pole.
4. Use a compass to find bearings and take headings
5. Relate bearings to degrees in a circle
6. Use bearings to make scale drawings of vectors or to describe vectors on a map.

Class Activities

1. Compare shapes of graphs obtained on homework assignments. Observe inverse relationship (as compared to the direct relationships previously observed with force and acceleration). Look at pattern obtained for distance and force--see if students can see that the force decreases faster than distance--that the relationship is more than inverse. Point out that inverse square relationships are common in physical phenomena (gravity, luminous intensity).
2. Inspect compasses. Demonstrate that needle a magnet--use small magnet to move needle. Observe which color points north. Point out "read bearing here" line, and demonstrate how to hold compass (waist level, aligned with body). Demonstrate dial degrees marked and arrow for boxing needle. Box needle by turning the dial or turning your body.
3. Explain that compass needle aligns with earth in the same way as small magnets or pin magnets yesterday. Have students suspend small magnets from thread again, observe that the side that points north repels the end of the magnet needle that points north. Review the fact that like poles repel...every magnetic pole that seeks north is alike, and is attracted to "magnetic north" (i.e. is opposite to magnetic north) and should be called a "north seeking pole". (Gega, p 317)
4. A. Procedure for taking a bearing. Face in desired direction, holding compass properly. Use dial to box needle. Read bearing.
   B. Procedure for heading in a given direction. Hold compass properly. Rotate dial to desired direction. Without resetting dial, turn body until the needle is boxed. Practice finding bearing of lines masking taped on floor, and of heading in various directions.
5. Discuss relationship of N, S, E, W to degrees on circle. Show how to find vector direction on a map. (Draw vector, align "read bearing here" line with north, turn dial until boxing arrow is over vector, read degrees). Show how compass can be used as 360 degree protractor.
6. Use centimeter grid paper to make small scale drawings of directions like "Go 2 cm at 27 deg, then 3 cm at 120 deg. How far are you from the starting point and what is your bearing.?"

   If time remains, have students write and trade simple orienteering directions. Mark start and finish positions with pennies so students can check directions. Start with bearing and pace, then add one turn.

Math Connection:

1. Problem solving strategy--finding a pattern; Graphical analysis
   Direct and inverse relationships
2,3,4,5 Measuring angles, degrees of an arc

Homework assignment:

TOPS Magnetism: Hairline compass (8) and Letter puzzles (9) (graded)
Gega: Electromagnets, pp. 345-345, 369-72. Read.

Physics 460--Daily Schedule

Session 16 The Connection between Magnetism and Electricity

Objectives:

1. To construct an electromagnet and describe how it works and what it is used for. To appreciate that electromagnets are temporary and work only when electricity passes through the coil.

2. To construct a galvanometer and describe its uses. To relate the galvanometer to an electromagnet

3. To construct a simplified version of an electric motor and understand how it works.

Class Activities:

Homework: Collect and answer questions

1. TOPS: Magnetism Build an electromagnet. Depending on available time, let students do this or demonstrate it. Slide core out and demonstrate that electromagnet works even without core. Reverse terminals on battery and demonstrate with a compass that poles of electromagnet are switched. Remind students that spinning electrons in atom caused magnetic moment, therefore "spinning electrons in a circular path" might cause analogous magnetic field. Describe various uses of electromagnets (doorbells, switches, cranes).

2. Construct a galvanometer (Instructions attached). Ask students to compare to electromagnet. Compare amount and direction of needle deflection in the presence of current. Discuss how to make it more or less sensitive. Display circuit tester and galvanometer as examples of these devices.

3. TOPS: Magnetism Hat pin compass (15) and Pin motors (16). Build devices. Discuss how they work. Demonstrate other small motors to try to identify similar parts.

Math connections: None

Teaching science: Gega: Chapter 6, How To Make Science Learning Centers, pp 135-147. Demonstrate extension activities: For older children--Tops: Magnetism Dots & Dashes (17), Does it Buzz (18), Off-on motor (19), Rice Roundup (20); Mc Cormack, Invention Convention: Magneta, the magic dancer. For younger children--Gega: activities from end of chapter.

Homework: Describe how you would set up and use a learning center on magnets for first or sixth grade.

Physics 460--Daily Schedule

Session 17 --Batteries, Bulbs and Electric Circuits

Objectives:

1. Discover alternate ways to light a bulb using a battery and a single piece of wire.

2. Identify the parts of a bulb and trace the path of electricity through it.

3. Identify alternative methods for creating circuits (battery holder, bulb socket, wire, Fahnestock clips or conducting ribbon, bulb holder made from clothespin and penny).

4. Build a simple circuit tester and trouble shoot simple circuits for loose connections, short circuits, bad batteries and bulbs

5. Identify electrical conductors and insulators.

Class activities: Using Science and Technology for Children: Electric Circuits.

In groups of four, have students brainstorm what they know and what they would like to know about electricity. Post sheets and leave until next week. Discuss QCC for electricity & magnetism, including how brief and broad the electricity objectives are.

1. Give each group a battery, a bulb and a piece of wire or conducting ribbon and a transparency and pen. Have each group light the bulb and draw their method of lighting it. Show transparencies to group, indicating what needs to be in a good picture (top, bottom of battery, top, side of bulb, location of wire). Give group activity sheet 1, p. 23. Have them predict, then try. Ask if there were any surprises.

2. Show students a clear household bulb with the base removed. Identify filament, glass support, support wires and attachment point. Explain function of ceramic insulator and vacuum inside. Explain that filament is a different kind of wire. Ask students to predict how many batteries will be required to light a household bulb. Start with the lowest number guessed and continue to add more until the bulb glows (about 20). (Batteries can be held in line between two meter sticks. Insulated wire about 5 feet long will be needed to reach bulb ends.) Bulb with base removed can also be lit in this fashion. Explain that these batteries connected end to end are in series, and that connecting cells in series makes more electron push, hence the bulb brighter.

3. Demonstrate methods of working with circuits (Battery holders, clips, wire, bulb holder (Gega, p. 349 and TOPS: Electricity: Build a circuit (8) using conducting ribbon, paper clips, rubber bands and pennies.) Describe the electron path in a circuit and explain the function of a battery (pump). Explain that cells change chemical energy to electrical energy and that wire is conduit to move electrons from the reaction losing them (-) to reaction gaining them (+). Demonstrate a switch.

4,5. Build circuit testers. Let half the groups prepare them with conducting ribbon (TOPS: Electricity: Conductor or Insulator? (6)) and the other half with wires (STC: Electric Circuits: Lesson 7). Discuss trouble shooting circuits (STC lesson 6). Then have them test assorted objects (golf tee, small piece of soda straw, brass screw, paper clip, piece of aluminum screen, piece of fiberglass screen, 1" piece of chalk, golf pencil sharpened on both ends, brad, wire nail, aluminum nail, marble, 1" piece of pipe cleaner, 1" piece of bare copper wire, 1" piece of bare aluminum wire. Have them sort into Venn Diagrams exactly as done in magnetism activity. Ask them to write a summary about what materials are electrical conductors. Compare results--Are all metals electrical conductors? Are all non metals non conductors? Introduce the term "Insulator". Point out that conductor/insulator is not an either/or categorization, but a continuum. Ask groups to turn in data sheet with Venn diagram for daily grade.

6. Demonstrate making a filament (STC: Electric Circuits, Lesson 8). Explain that the nichrome wire is a high resistance wire, and that we use them when we want to make a device to produce heat and light.

Math connections: Venn diagrams

Teaching science: Georgia curriculum for electricity.

Homework: Gega: Chapter 12, pp. 338-349. Read. Activity: Paper clip switches, p. 352. Prepare and bring to class with a written explanation of how the double switch works (question 3b, p. 353).

Physics 460--Daily Schedule

Session 19 More about circuits and electrical devices.

Objectives:

1. To discover how electrical resistance varies with length, diameter and composition of a wire. To identify some common devices that work as a result of the heat or light produced by electrical resistance.

2. To define and use correctly the terms "volts, Ohms, amps, current, resistance and potential difference."

3. To discover the effects of connecting cells and resistors in series and parallel.

4. To draw simple circuit diagrams using accepted symbols, and predict the flow of electrons through those circuits.

Class activities:

1. TOPS: Electricity, Resistance in a wire (14), A flashy experiment (15). Summarize that resistance depends on material, increases with length (direct proportion), increases as thickness decreases (inverse proportion, actually depends on cross sectional area). Demonstrate activities from Gega, "How Can You Make a Dimmer Switch?(p. 368) and "How does a fuse work?"(p. 369). Show actual dimmer switch and fuse, and ask which resistance property is being illustrated.

2. Explain that a light bulb is a resistor and that different resistances produce different amounts of light. Discuss how a 40 Watt and 100 Watt bulb look different when the same amount of current pass through them and theorize as to why. Introduce Ohm as the term for resistance, defer discussion of Watts until later. Introduce amp as the quantitative term for the amount of electric current, and remind students that this is the fundamental unit. Introduce volt as a unit of electrical work.

3 4. Work in groups of 4.
Series circuits: Gega, pp. 354, 355. Parallel circuits, Gega, pp. 356-7. Explain the symbols used in a circuit diagram. Use attached data sheet, and collect for participation grade. Explain that connecting cells in series increases voltage (one pushes, then the other pushes). Connecting cells in parallel increases amperage (amount of electron flow--Gega, Fig 12-5). Connecting resistors in series means that each bulb must share voltage (will share evenly only if they have same resistance). In parallel, each bulb has an independent path to the cells so each one receives full voltage (they will be same brightness if they have same resistance).

Math connection: Word problems, dimensional analysis, symbolic representation

Homework: Problem sheet. Gega, pages 180-189, Assessment. Read

Physics 460--Daily Schedule

Session 20--Circuit wrapup, Electrical Generation, Alternating vs. Direct Current.

Objectives:

1 To quantify the relationships between current, resistance and potential in series and parallel circuits.
2. To use a magnet to generate electricity, and explain how that process works and why the current generated is alternating.
3. To compare similarities and differences in various energy sources used in generating electricity. Identify various components of electric power plants.
4. To describe methods for assessing student achievement of electrical objectives

Class activities:

1. Work in groups of four. TOPS: Electricity, Surprise Circuits (16). After building the two circuits and allowing students to explain them, deal with the following questions: Does the absence of light in circuit 1 mean that no current was flowing through the bulb? In circuit 2, what is different in the bulbs when the left switch is closed: voltage or amperage? How can we calculate what is happening in circuits containing different resistors? Worksheet attached.

2. Explain to students that up until this point we have been generating electricity chemically--with a battery. The current we have been using is direct current. It always flows one direction, and continues to flow until the chemical reaction stops as long as the circuit is closed. That's not how the electricity for our homes is generated. The current in our homes is alternating current. It changes direction 60 times a second (60 cycle). How is AC generated?

Remind students that electricity could be used to make a magnet. Remind them about galvanometers and detecting the flow of electricity. Demonstrate induction coils made from wire & toilet paper rolls. (TVA Energy Sourcebook, Grade 6, Copies enclosed). Demonstrate bicycle generator. Explain why rotation of magnet produces alternating current.

3. Use diagrams of electric power plants. Discuss the differences in energy source as being the method for turning the turbine. Discuss environmental impact of each energy source.

If time is available, plan trip to electric generating facility.

4. Discuss objectives for this unit. Describe various ways to assess achievement. Discuss student assessments, pp. 89-95 STC: Electric Circuits. Show Teacher Record Chart, p. 98 and discuss how to collect that data. Show some assessment items from TOPS.

Math Connection: Fraction applications

Teaching Science: Assessment Skills

Homework: Safety Handout from Middle Grades Curriculum Guide

Physics 460--Daily Schedule

Session 21--Safety and Equipment Guidelines for the Elementary and Middle School.

Objectives:

1. Describe the most common science related accidents and methods of prevention.
2. Identify sources of safety information.
3. Identify equipment that needs to be purchased and stockpiled to make the teaching of science easy.

Class activities:

1. Discuss information in safety handout. Describe safety goggle requirement.
2. Discuss other sources of safety information. NSTA publications, Flinn Catalog/Safety Manual, High School Teachers, Georgia Department of Education.
3. Discuss importance of school accident and reporting procedures.
4. Provide list of common equipment. Display items that must be purchased (measuring equipment, hotplates, microscopes). Indicate age appropriate types. Tour equipment area to demonstrate storage options (eg. by equipment type or unit.

Physics 460--Daily Schedule

Bibliography--Physics 460
Books

Bennett, Albert & Nelson, Ted. Mathematics for Elementary Teachers (DuBuque IA: William C. Brown, 1992).

Gartrell,Jack E. Methods of Motion. Washington DC: National Science Teachers Association, 1992.

Gartrell,Jack E. & Larry E. Schafer. Evidence of Energy. Washington DC: National Science Teachers Association, 1990.

McCormack, Alan J. Inventor's Workshop. Carthage IL: Fearon Teacher Aids, 1981.

Marson, Ron. Electricity. Canaby OR: Tops Learning Systems, 1984.

Marson Ron. Magnetism. Canaby Or: Tops Learning Systems, 1985.

Marson, Ron. Metric Measuring. Canaby OR: Tops Learning Systems, 1987.

Marson Ron. More Metrics. Canaby Or: Tops Learning Systems, 1985.

Science Curriculum Improvement Study. Relative Position & Motion. Berkley CF: Regents of the University of California, 1972. Available on CDROM: Science Helper K-8 or in modified form from Delta Education.

Tennessee Valley Authority. Energy Sourcebook: Grade 6. Knoxville, TN: TVA,

Texas Tech University. Strategies for Teaching Physical Science. Lubbock TX: Science and Mathematics Education Center, no date.

Wiebe, Arthur, Larry Eklund, Sheryl Mercier, Ed., Floaters and Sinkers. Fresno CF: AIMS Education Foundation, 1987.

Wiebe, Arthur, Larry Eklund, Sheryl Mercier, Ed., Magnetism. Fresno CF: AIMS Education Foundation, 1987.

Other

Eureka! Videotapes produced by TV Ontario, 1981. Available from Films for the Humanities and Sciences. Some Georgia school systems may have this series as it was a part of the state video library.

Toys in Space Videotape.

SELECTED ACTIVITIES

Physics 460
Mass and Volume Activities

1. Capacity and volume

Obtain two graduated cylinders of different sizes. Fill them between one third and half full of water. Record the volume of water in the cylinder in the table below. Have another group member verify your results. Empty a little of the water and repeat the procedure. Be sure to read the bottom of the meniscus and to record the measurement with the appropriate number of decimal places.

Capacity of cylinder	Smallest scale division	Amount of water
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Determining the volume of an object

There are three methods which are commonly used to determine the volume of an object.

1. Measure all the dimensions with a linear measuring device and use a formula to compute the volume. (e.g. $V = (l)(w)(h)$ for a rectangular solid or $V = \pi r^2 h$ for a cylinder)
2. Determine the area of the base by drawing and counting on grid paper and then measuring the height of the object. Again, the object has to be a regular solid with perpendicular sides.
3. Water displacement. Put some water in a graduated cylinder and record the initial volume of water. Submerge the object and measure the final volume. (Final - initial) volume is the change in volume due to the submerged object and is equal to the object's volume. If the object floats, you will have to submerge it, using the thinnest possible probe, like a paper clip. Consider tying a thin string around the object being submerged so you can get it out without emptying the whole cylinder.

Select at least three different shaped and sized objects. You may choose from objects I have provided or objects in the room or your book bag, etc. First estimate then measure their volume, using an appropriate method. Tell why the method you chose is appropriate. For example, measuring with a ruler is a better method than water displacement for obtaining the volume of soap because soap dissolves in water. Water displacement is the only appropriate

method for measuring the volume of a stone because its shape is irregular. Make a data table to record your measurements. Keep your objects.

3. Mass

Obtain three sizes of washers. Measure the mass of the washers using standard weights or centicubes. Use both a platform and a pan balance. Check the mass on the electronic balance. Bake a data table below for your results. Be sure that each measurement is recorded to the proper number of decimal places.

4. Conversions

Measure the mass of one or more of your selected objects from step 2 in washers. Convert that measurement to grams, using a unit factor method. Check your conversion by finding the mass of the same object on the electronic balance. Remember that the two measurements will probably **not** agree perfectly because the electronic balance is a more precise instrument. If your converted value is within 10% of the value shown on the electronic balance, you both massed and converted correctly.

Unit Factors

A unit factor is a fraction which expresses an equality. The denominator in a unit factor has a numeric value of 1.

If 20 washers = 50 grams, you can write two conversion factors, both of which are true:

$$\frac{20 \text{ washers}}{50 \text{ grams}} \qquad \frac{50 \text{ grams}}{20 \text{ washers}}$$

(Remember, a division sign can be read "per")

If we divide the denominator into the numerator, the numeric value of the denominator will be 1 and you will have a unit factor:

$$\frac{20 \text{ washers}}{50 \text{ grams}} = \frac{.4 \text{ washer}}{1 \text{ gram}} \qquad \frac{50 \text{ grams}}{20 \text{ washers}} = \frac{2.5 \text{ grams}}{1 \text{ washer}}$$

Metric Measure

Fundamental quantities are those which must be defined. There are four master measures on which all others depend: length, mass, time, and temperature. They establish the fineness with which man can examine the physical universe, and they provide the basis for all technology.

Fundamental units are the basic units from which all others will be derived.

Derived quantities are those which are related to fundamental quantities by a definition or defining formula.

Derived units are related to fundamental units by a conversion factor. For example, centi- = 1/100 **basic unit** or 1 **m** = 39.37 in. or 1 hr. = 60 **sec.** (The fundamental units in the foregoing examples are in bold type.) Metric prefixes are conversion factors for obtaining derived metric units.

Length - The fundamental quantity

Fundamental unit -

How big is it?

Historical definition -

Contemporary Definition (1960) - 1,650,763.63 wavelengths in a vacuum of a particular spectral emission line of krypton 66 at 1210 deg. C is defined as one meter.

Derived units -

Derived quantities and their units:

Quantity	Sample Units	Measures
Area		
Volume		
Liquid capacity		

Mass - the fundamental quantity

Fundamental unit -

How big is it?

Historical definition -

Contemporary definition - Mass of prototype kilogram #1 kept at the International Bureau of Weights and Measures at Sievres, France.

Derived units -

Derived quantities which include mass (only one example; there are many)

Density -

Time - the fundamental quantity

Fundamental unit -

How big is it?

Historical definition -

Contemporary definition - 9,192,631,770 cycles of frequency associated with the transition between two hyperfine levels of isotope cesium 133.

Derived units - (Note: customary units are not metric, but metric prefixes are some times used; eg., millisecond)

Derived quantites which include time (only one example; there are many)

Speed or velocity - length/time
example: meters/second

Temperature - the fundamental quantity

Note: temperature is different from heat

Fundamental unit -

How big is it?

Historical definition -

Contemporary definition - 1/276.16 of the thermodynamic temperature of the triple point of water (0.01 degree Celsius)

Derived units -

Derived quantities which include temperature (one example; there are many)

Heat (in calories) - 1 calorie is defined as the amount of heat needed to raise the temperature of 1 gm. of water 1 degree C. (mass)x(temperature)

Scientific Internationale; Other Quantities

Scientists use a system called SI (Scientific Internationale) which is metric in nature. Three other basic quantities and units are defined. They are:

Electric charge: Ampere
Luminous intensity: Candela
Chemical equivalent: Mole

There are also a few other measurements which do not depend on the basic standards. Those are:

Angle measurement, which is the ratio of two lengths and is thus independent of any length unit; and
Color measurements, which are really schemes of classification related primarily to the properties of the human eye.

A worldwide universal measurement system was established in 1870 by international treaty (Treaty of the Meter, 1875).

The power to regulate weights and measures was reserved to the federal government by the Commerce Clause of the U. S. Constitution. The office that does this is the National Bureau of Standards.

Yards, pounds, and gallons are legally defined in the U. S. in terms of the international metric standards. The use of the metric system in this country was legalized in 1866.

Pharmacists in the U. S. have used metric since the 1950's. The U. S. armed services have been using metric since about 1960. In 1975 Congress passed the Metric Conversion Act calling for a voluntary changeover. By 1986 only four other countries, Brunei, Burma, Liberia, and Yemen, were not using the metric system, and all are committed to it, either legally or by preference.

ACKNOWLEDGEMENTS

This program was developed at Texas Tech University with funds made available by Public Law 98-377, Education for Economic Security Act, Title II, and administered by the Science Section, Division of Curriculum Development, Texas Education Agency (TEA) Austin, Texas.

Project coordinators for the Texas Education Agency were Joseph J. Huckestein, Ed.D., Director of Science; Barbara ten Brink, Ph.D., Science Specialist; Kamil Jbeily, Ph.D., Education Specialist.

Kamil Jbeily, Ph.D., represented the TEA on the Advisory Board and supervised the project. Other members of the Advisory Board were: Richard Abbondanzio, St. Mark's School of Dallas, Dallas; Anne Benham, University of Texas at Arlington, Arlington; Barbara Foots, Houston ISD, Houston; Robyn Ford, Amarillo High School, Amarillo; Paul Garza, Highland High School, San Antonio; and Kay Reat, Mackenzie Junior High School, Lubbock.

Special appreciation is extended to the students from Mackenzie Junior High School, Lubbock ISD, their teacher Kay Reat, and their principal, Michael Bennett, for their contributions in the development of the video tapes that are a vital part of the project.

Other individuals who contributed to this project are as follows: Kay Reat, teacher, Mackenzie Junior High School, Lubbock ISD; Susan Talkmitt, teacher, Hutchinson Junior High School, Lubbock ISD; Ethel Forman, teacher, Hutchinson Junior High School, Lubbock ISD; Cynthia Chambers, Media Specialist, Texas Tech University; and Cheryl Carroll, Project Secretary.

CONCEPT MAPPING

There is a growing recognition that students learn science in much the same manner as scientists construct knowledge (Novak, 1989). Scientists work with existing concepts and constructs to form ideas to account for their observations. Students also use their existing concepts and constructs to develop new meaning. The view that students create meaning for themselves using complex representations or schema is constructivism. Joe Novak, a theorist and strong proponent of constructivism, argues that the process of using current conceptual ideas to find answers to problems and to create new knowledge is a continuing and lifelong process for individuals who seek to understand the world (Novak, 1989).

Many individuals have misconceptions that interfere with their understanding of the natural world. For example, many elementary students perceive the Earth is flat. All students have misconceptions about gravitational forces. Direct laboratory experiences will challenge many of the misconceptions students have and help them develop new meaning.

Joe Novak and his colleagues at Cornell University have devised two tools, concept mapping and the Vee heuristic, that help teachers and students better understand how new knowledge is learned and created. These tools also help students identify student misconceptions.

Concept mapping is based on the learning theory of David Ausubel which asserts that concepts derive their meanings through connections or relationships with other concepts, and that meaningful learning occurs when new knowledge is consciously linked to relevant concepts or propositions already possessed by the learner. Ausubel's theory of meaningful learning is based on the assumption that the most important single factor influencing learning is what the learner already knows. In meaningful learning, new concepts are linked to existing concepts. While meaningful learning can occur in several ways, the most important way is when learners link new specialized concepts to more generalized, higher-order concepts which form a part of the learner's existing structure of knowledge.

Concept maps are a means of representing the relationship between "concept words" and "linking words" that show a hierarchical arrangement of the relationships between them. A "concept" is defined by Joseph Novak as a regularity in events or objects identified by a symbol (the concept label or name) that is utilized to determine meaning.

Concept mapping is a visual representation of cognitive structure. It has four major components: concepts, relationships (propositional linkages), hierarchy, and cross-links. First, concepts are what we think with. Second, concepts are related to each other by linking words. Two concepts with a labelled relationship form a "proposition". Third, the concepts are linked together into a hierarchy from the most general concept at the top of the map to progressively more specialized concepts at the bottom of the map. Finally, cross-links are relationships that are made between concepts in two different domains on the map. These connections are significant because they point out interrelationships.

A "good" concept map has many concepts, levels of hierarchy and cross-links. No two concept maps are identical. Each student's map represents a personalized view of a given area of knowledge. A completed concept map represents an understanding of the relationships entailed by an important set of concepts and effectively communicates this understanding to others.

Concept maps teach students how to learn effectively. Too often students memorize facts which are forgotten within a few weeks. In contrast, concept maps help students link new information with existing relevant concepts which then undergo further development or differentiation.

Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377

Step 2: **Identify** the major concepts (object, events) by listing or underlining. (Each of the concepts can be copied onto a separate small card for easy rearrangement).

Step 3: List or **rank** the concepts from the most inclusive (most general) to least inclusive (most specific). For example: "states of matter" (most general) then "solid", "liquid", "gas" (more specific).

Step 4: **Arrange** the most general concept at the top of the map. Link it to less inclusive concepts. Label all lines with linking words that explain how each pair of concepts is related. The map should read top to bottom.

Step 5: Try to **branch out**. Add two or more concepts to each concept already on the map.

Step 6: Make **cross-links** between two concepts that are already on the map. Label all cross-links with words that explain how the concepts are related. Draw these links with an arrow so the reader will read in the intended direction.

Because of the flexibility of concept maps, they can be used for several different purposes. These uses are (1) as curricular tools; (2) as instructional tools; and (3) as a means of evaluation. As curricular tools, concept maps can be an important tool to focus the attention on the teaching of concepts and on the distinction between curricular content that is to be learned and instructional content which is to serve as a vehicle for learning. A completed concept map is the cognitive component of the curriculum and portrays the structure in a discipline. Concept maps can be used to chart change in student understandings and misconceptions over time.

The concept map as an instructional tool can be used to plan a lesson, integrate a series of lessons, and supplement lectures, laboratories, and readings, and the text. They can insure that organization exists. It is important to have students construct concept maps. Concept maps can be useful in evaluating student knowledge. Essay questions can be replace by a mapping exercise where the students are given concepts and must construct a map.

Graphic Organizers

The graphic organizer is a diagrammatic representation of the basic concepts of a unit/topic/etc. that shows relationships among the concepts represented by the words. It is more pictorial and visual than verbal organizers. The graphic elements help construct a framework of vocabulary and concepts for the learner. The graphic organizer is made the same way as a concept map except propositional statements are not used.

References:

Bodulus, J. (1986). Concept mapping by mapping by computer. *Science Scope*, 9(4): 16-17, April.

Heinze-Fry, J., Crovello, T. J., and Novak, J.D. (1984). Integration of ansubelian learning theory and educational computing. *The American Biology Teacher*, 46(3): 152-156, March.

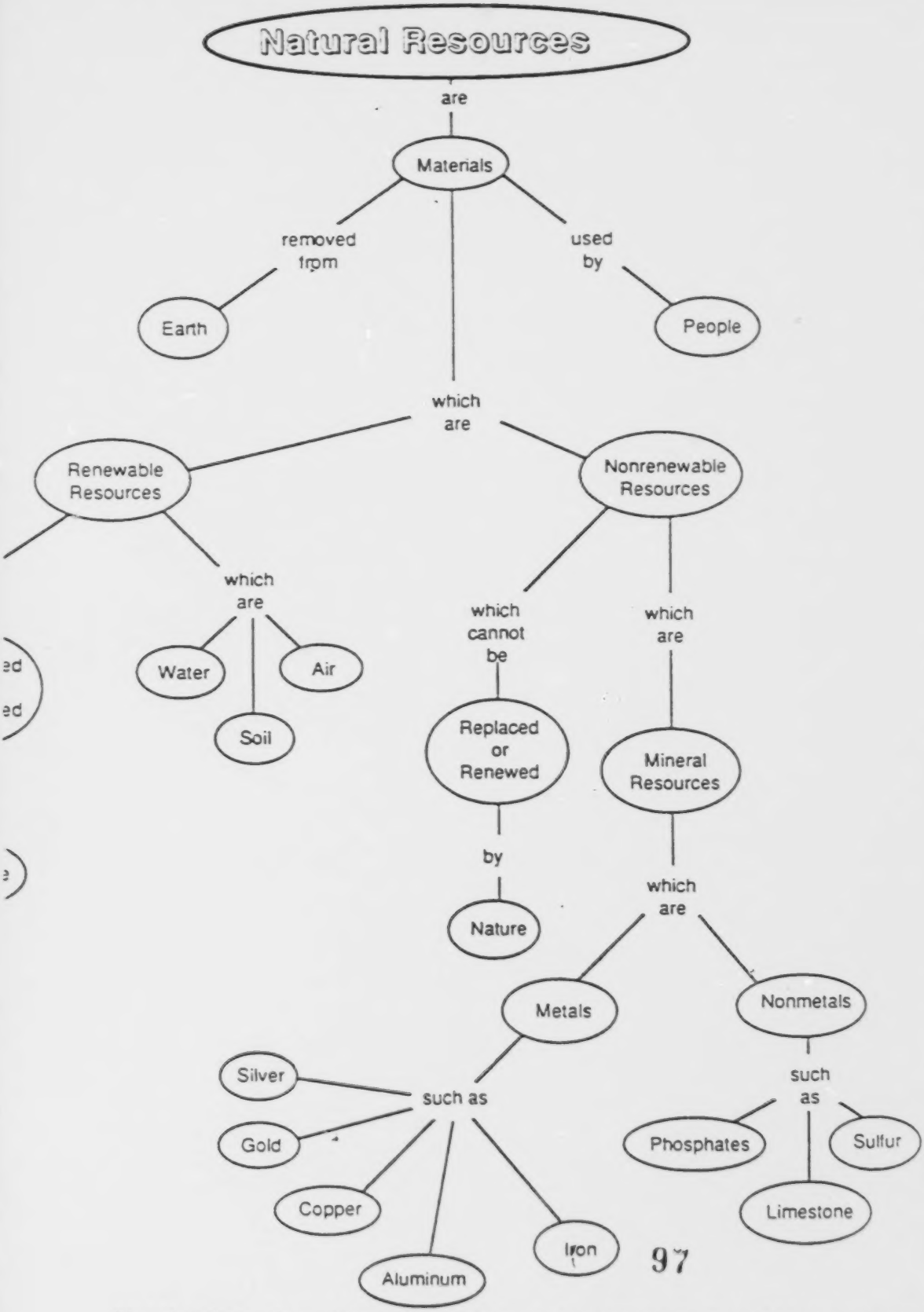
Novak, J. Applying learning psychology and philosophy of science to biology teaching. *The American Biology Teacher*, 43(1): 12-20.

Novak, J. (1980). Learning theory applied to the biology classroom. *The American Biology Teacher*, 42(5): 280-285, May.

Novak, J. (1989). The role of content and process in the education of science teachers. *Gifted Young in Science*, P. F. Brandwein & A. H. Passaw (ed), Washington: National Science Teachers Association, p. 307-319.

Novak, J.D. and Gowin, D. B. (1984). *Learning how to learn*. New York: Cambridge University Press.

Stewart, J., Vankirk, J., and R. Powell (1979). Concept maps: a tool for use in biology teaching. *The American Biology Teacher*, 41(3): 171-175, March.

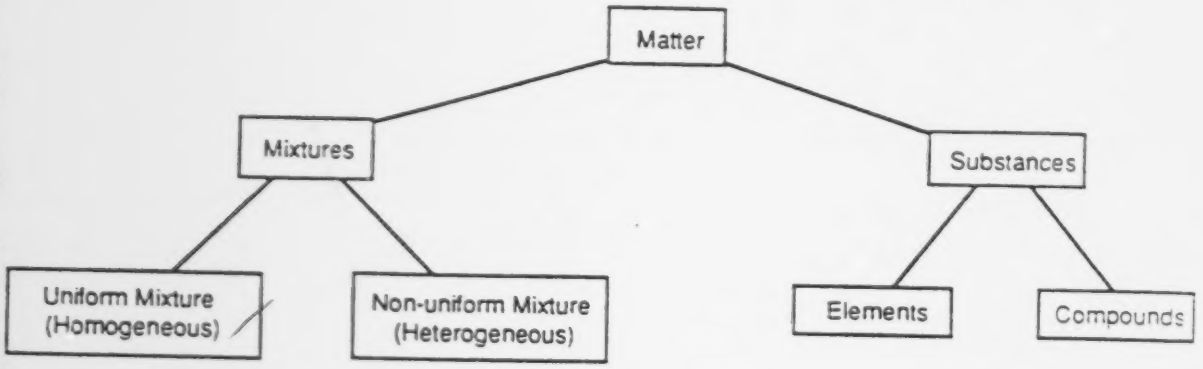


Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377.

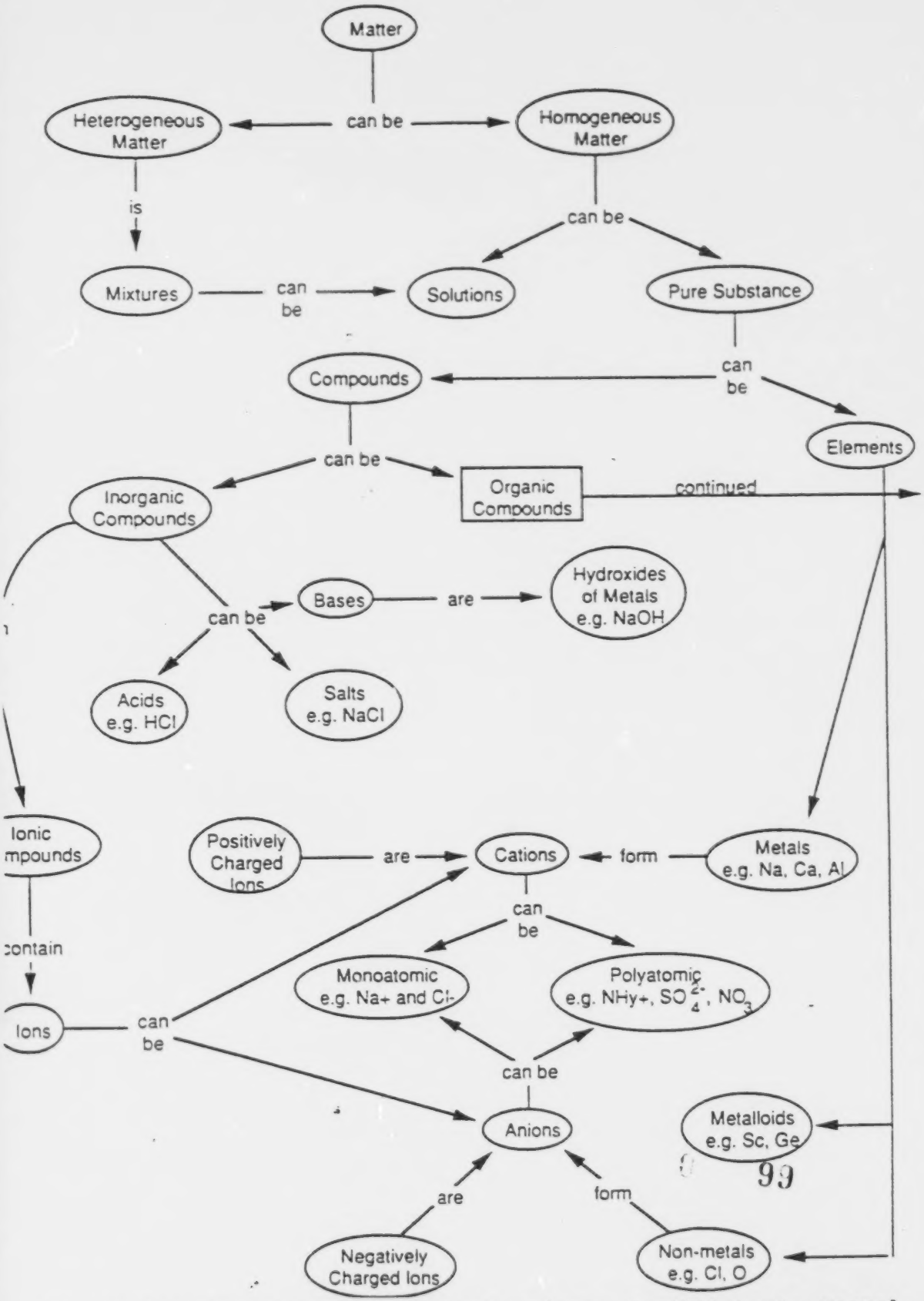
MATTER

Matter is anything that has mass and takes up space. Matter has several different properties such as mass, weight, volume, and density. Mass is the amount of matter in an object. Weight is a measurement of the force of gravity. Weight and mass are not interchangeable terms and cannot be substituted for each other. Volume is the amount of space an object occupies, and density is defined as mass per unit volume (D=M/V). Matter exists in four different phases, solid, liquid, gas, or plasma, and each of these exhibits physical and chemical properties. A physical property is a charactenstics of a substance that can be observed without changing the nature of the substance while a chemical property is a characteristic that describes how a substance reacts with another substance.

Matter consists of mixtures and substances. Mixtures are two or more materials that may be combined in any amount and are easily separated by physical means. They may be heterogeneous, with different properties, or homogeneous, with identical properties. Substances are either elements, which cannot be broken down further, or compounds, which are composed of two or more elements. Matter is described by the kinetic theory which states that all matter is in constant motion, and the amount of motion determines if the material is a solid, liquid, or gas. In addition, matter may undergo two types of changes. In a physical change the material retains its original properties. In a chemical change a new material with different properties is formed.



rategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377.



Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone

WORK AND ENERGY

Work is accomplished if an object is moved a distance as a result of the action of a force. The direction the object moves must be the same as that of the applied force in order to accomplish work. Work is calculated using the formula:

$$\text{Work} = \text{force} \times \text{distance}$$

The unit of work measurement is the joule.

Simple Machines: Work is made easier by the use of simple machines. Some increase the effort force or the mechanical advantage, whereas others increase the distance or the speed an object moves. The six simple machines are the lever, wedge, inclined plane, screw, pulley, and wheel and axle. Some machines are combinations of these simple machines.

Power: The rate that work is done is termed power. Power is the amount of work accomplished per unit of time.

$$\text{Power} = \frac{\text{work}}{\text{time}}$$

Efficiency: The efficiency of a machine is a ratio of the work output to the work input. Efficiency is usually expressed as a percent.

$$\%\ \text{Efficiency} = \frac{\text{work output}}{\text{work input}} \times 100$$

Energy is defined as "the ability to do work". Energy is necessary for a body to exert a force. Energy has two forms, kinetic and potential. Kinetic energy can be changed to potential energy and visa versa; yet, energy must be conserved.

Kinetic energy is the energy of motion. The kinetic energy of a body depends on the mass and the velocity of the body. An increase in the velocity of an object increases the kinetic energy of the object. The change in kinetic energy is equal to the work accomplished.

Potential energy is the energy of position. A book held high in the air has the ability to do work if it is released in order to fall to the ground. If the book is raised to a greater height, the amount of potential energy is increased. This change in potential energy is equal to the work done on the book.

The change in kinetic energy and potential energy is equal to the work done. Work and energy have a direct connection. As a result, the joule is the unit of measurement for both.

Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377

MOTION

An object is in motion if it changes position when compared to a frame of reference. For example, an observer standing on the street notices the motion of a car as it passes. The frame of reference here is the earth. The motion of the moving car does not appear as fast to the observer if the observer is also moving in a car. The frame of reference is now a moving car.

Motion is measured in speed and calculated as the distance traveled during a unit of time. The unit of speed is meters per second. Speed and velocity are terms that are mistakenly interchanged. Velocity is a more specific term; it refers to distance per unit of time in a particular direction. The velocity of an object includes meters/second as well as the direction of motion. If the velocity of the object changes, the object accelerates. Acceleration is the velocity change per unit of time. Thus the unit is meters/second^2. Acceleration can increase or decrease depending upon the change in velocity. However, acceleration also changes if the direction of motion changes. Therefore, acceleration can be defined as the rate of velocity change, referring to either magnitude or direction. A change in magnitude represents linear motion. A change in direction represents circular motion. When an object moves in a circular path or in circular motion, the direction of motion changes. Even though the velocity does not increase, the object shows acceleration.

A force provides the necessary energy to set an object into motion, change the speed or direction of an object in motion, or stop the object in motion. A force can be defined as a push or a pull. When a force is exerted on a mass, the mass exerts an opposing force. Motion occurs or changes if these opposite forces are unequal or unbalanced. If the forces are equal or balanced, motion is unaffected.

Isaac Newton (1642-1727) summarized three famous laws that explain motion.

First Law: An object at rest or moving at constant velocity does not change its state of motion unless an unbalanced force acts upon it. This is often referred to as the law of inertia. Inertia is the tendency of an object at rest to stay at rest or for an object in motion to stay in motion. Inertia is demonstrated by a passenger being thrown forward in a car as the car comes to a sudden stop. The passenger in motion stays in motion as the car stops.

Second Law: If an outside force acts on an object, the change in motion is proportional to and in the same direction as the outside force. This law is written in the equation form: Force = mass x acceleration. This law is demonstrated by striking a baseball with a bat. The mass of the baseball does not change; yet, if the force striking the ball is increased, the acceleration of the baseball increases.

Third Law: For every action force there is an equal and opposite reaction force. A person jumping on a trampoline demonstrates this law. As the person hits the trampoline with a downward force, the trampoline exerts an equal and opposite force that forces the person upward.

A force has been described as a push or a pull, yet some specific forces need to be considered in the study of motion. These include friction and gravity.

Friction is a force which opposes motion. This force acts in a direction opposite to the direction of motion. Friction opposes motion among solids as well as among liquids and gases; in fact, air resistance is a type of friction. However, resistance opposing solids is usually greater. Wheels, ball bearings, and lubricants help solids overcome friction. Friction can also prove beneficial as it helps prevent the sliding of a car on ice.

Gravity is the attractive force between all objects in the universe. Near the surface of the Earth, this force causes an object to fall at a rate of 9.8 meters/second^2. This number varies slightly on the Earth's surface because the Earth is not perfectly round; yet, 9.8 meters/second^2 is the accepted acceleration rate. All objects on Earth fall at this acceleration rate, regardless of mass. Galileo (1564-1642) demonstrated that all objects fall at the same rate even though the masses are different. However, a feather falls at a slower rate than a rock because of air resistance. In a vacuum these objects would fall at the same rate.

The weight of an object is determined by the force of gravity acting on the object. The weight on Earth is calculated:

weight = mass of object x Earth's gravitational acceleration rate

Thus, the weight of an object on Earth having a mass of 10kg would be calculated:

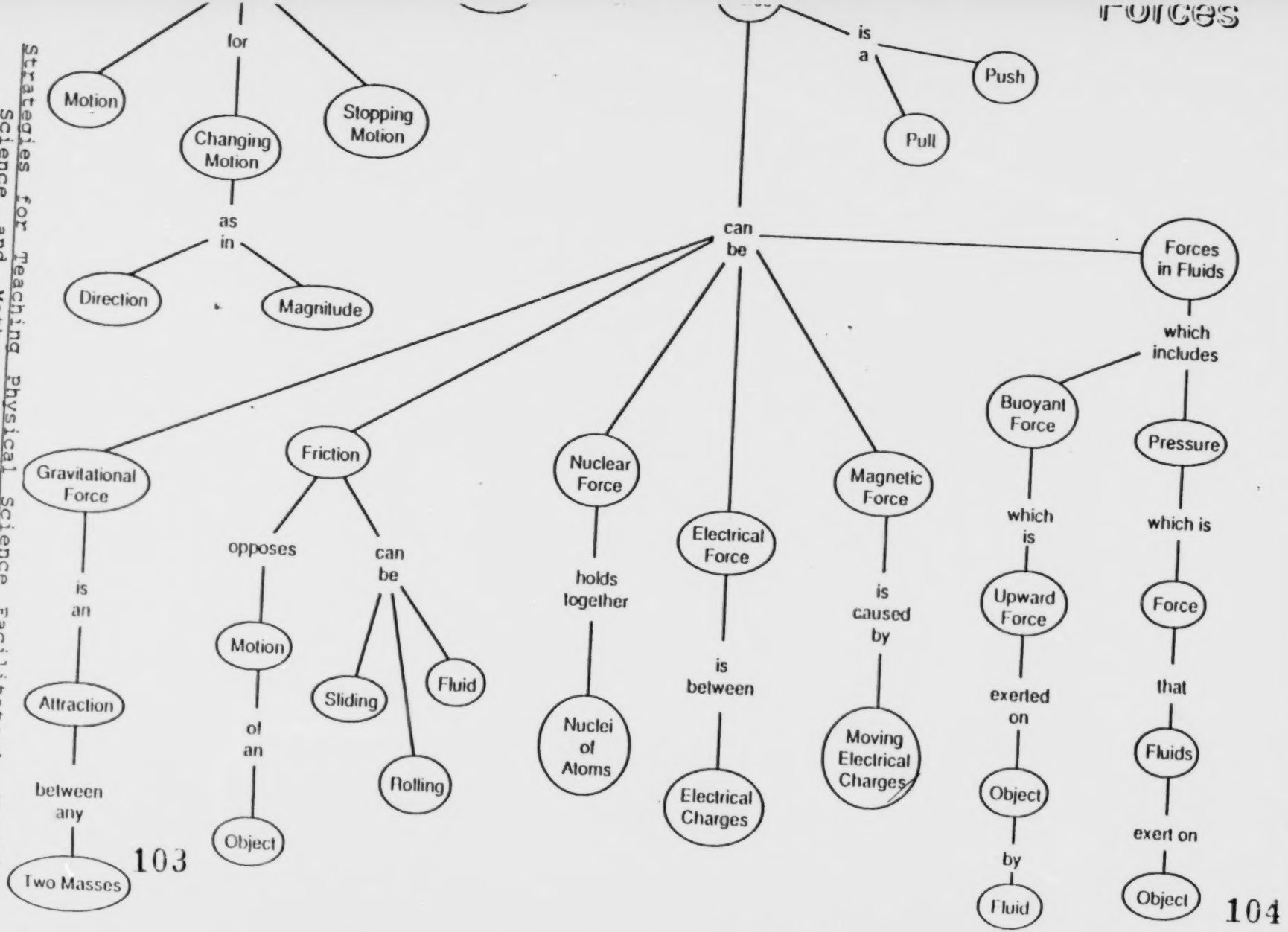
weight = 10 kg x 9.8 m/s^2 = 98 Newtons

Newton is the unit of force and of weight which is a measurement of gravitational force. The force of gravity on the moon is approximately 1.7 meters/second^2. Thus, the weight of the same object having a mass of 10 kg would be calculated:

weight = 10 kg x 1.7 m/s^2 = 17 Newtons

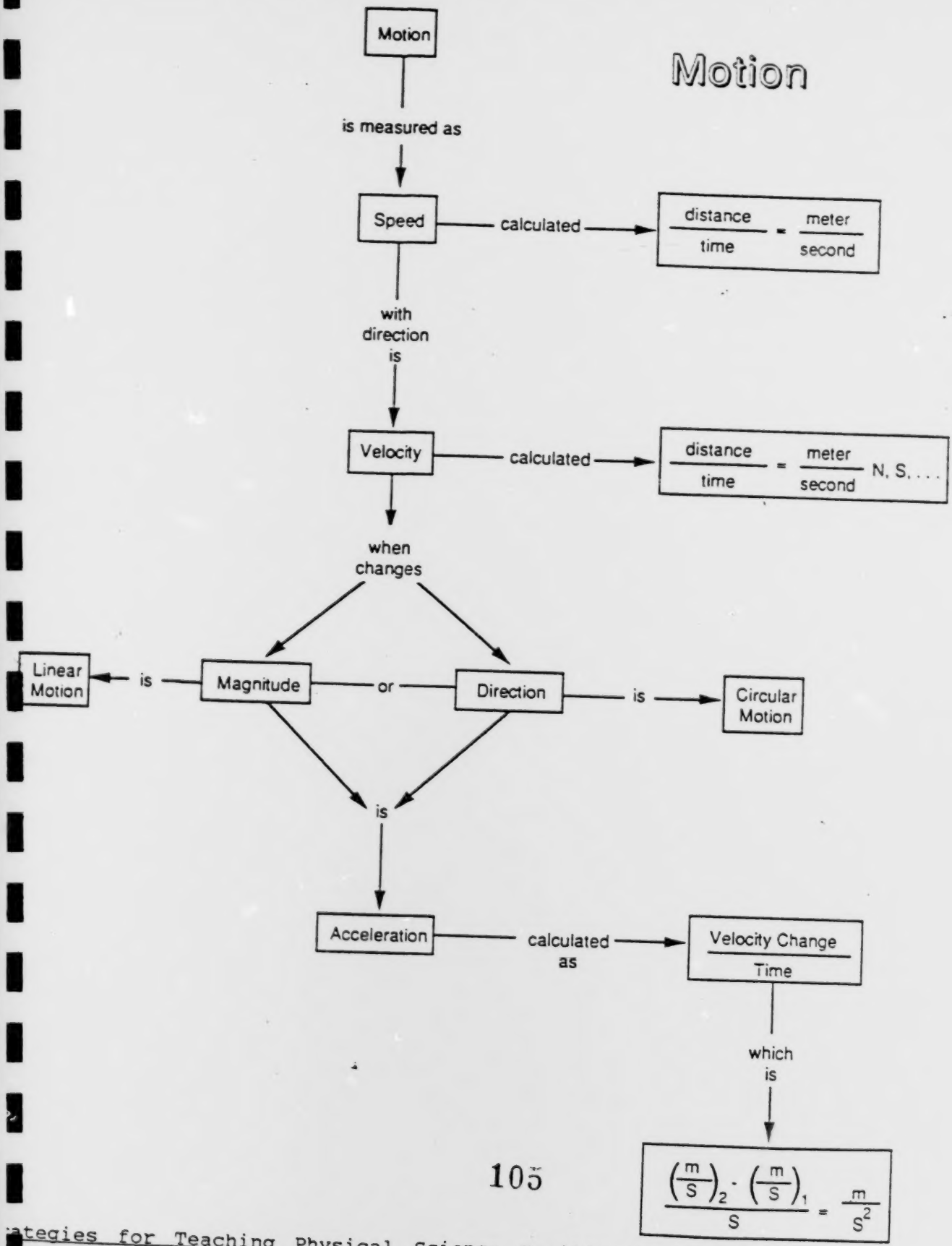
The weight of this object would be less on the moon. The weight of an object will vary on different planets and on the moon because of different rates of gravitational acceleration on these bodies. The mass of the 10 kg object does not change although the weight changes. Weight and mass are not synonymous terms; they are not interchangeable. Mass is the amount of matter in an object, and this does not change. Weight, on the other hand, is the mass of the object multiplied by the gravitational acceleration rate created by the force of gravity of a universal body.

Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377.

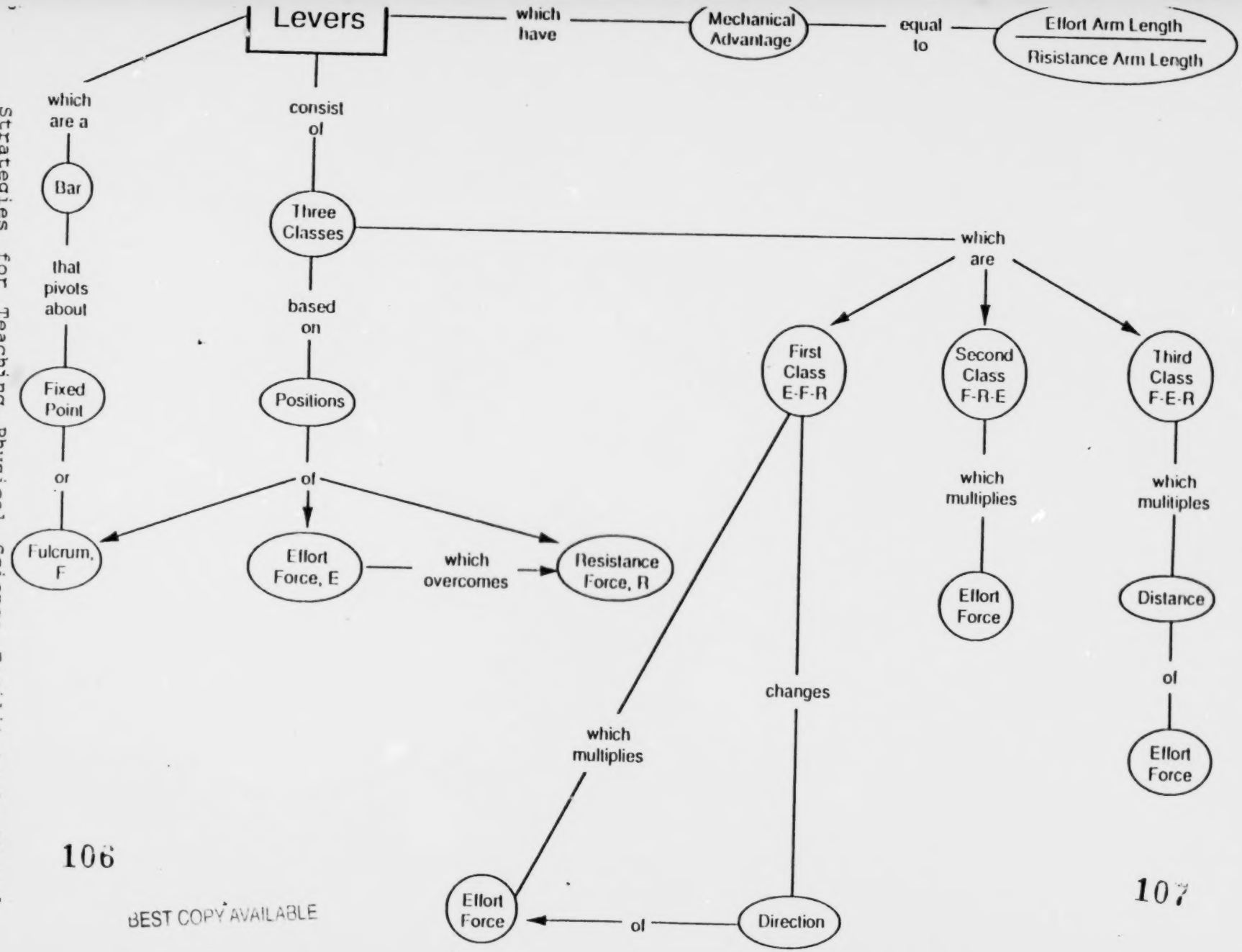


Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone

Motion



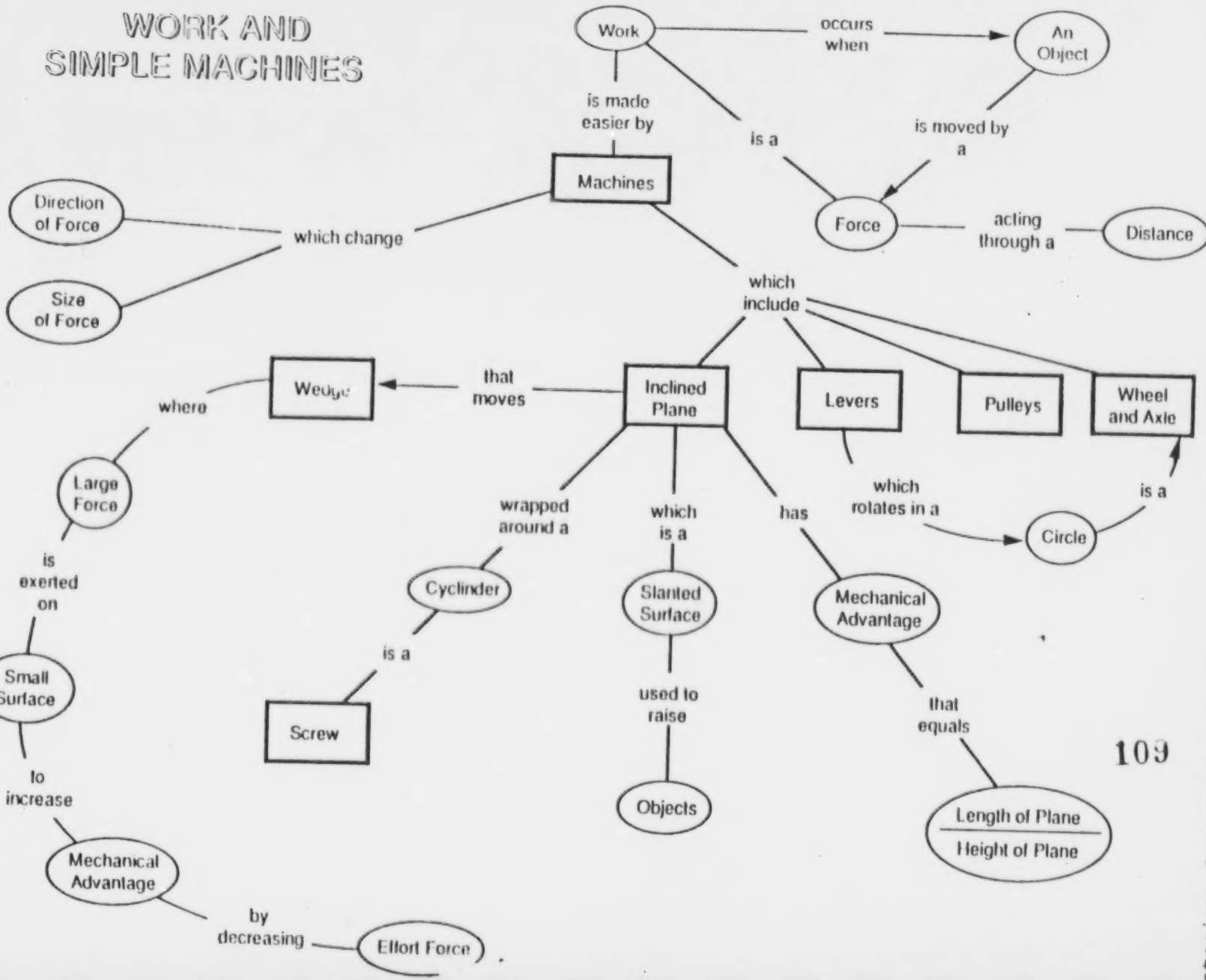
ategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377



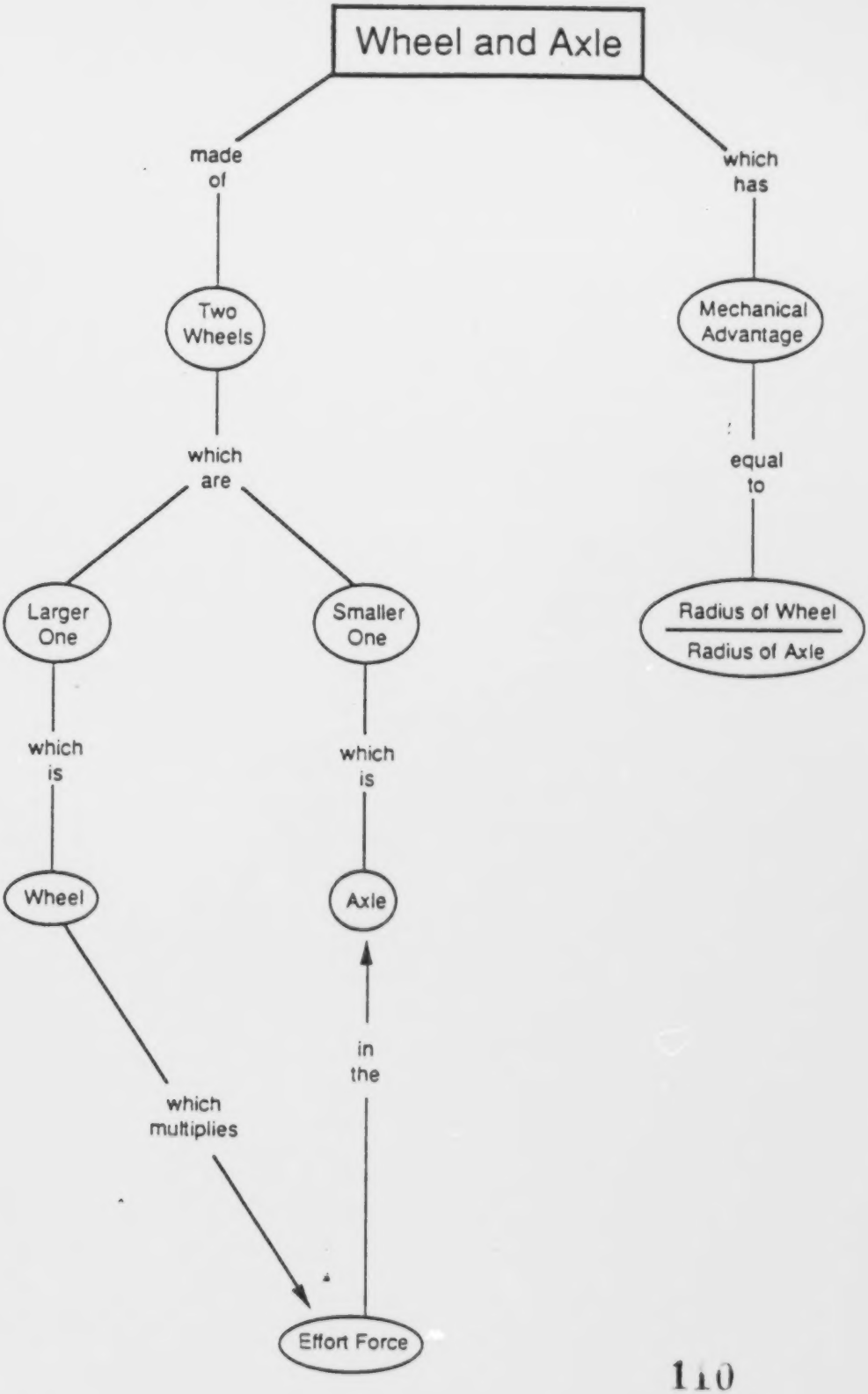
BEST COPY AVAILABLE

Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas phone

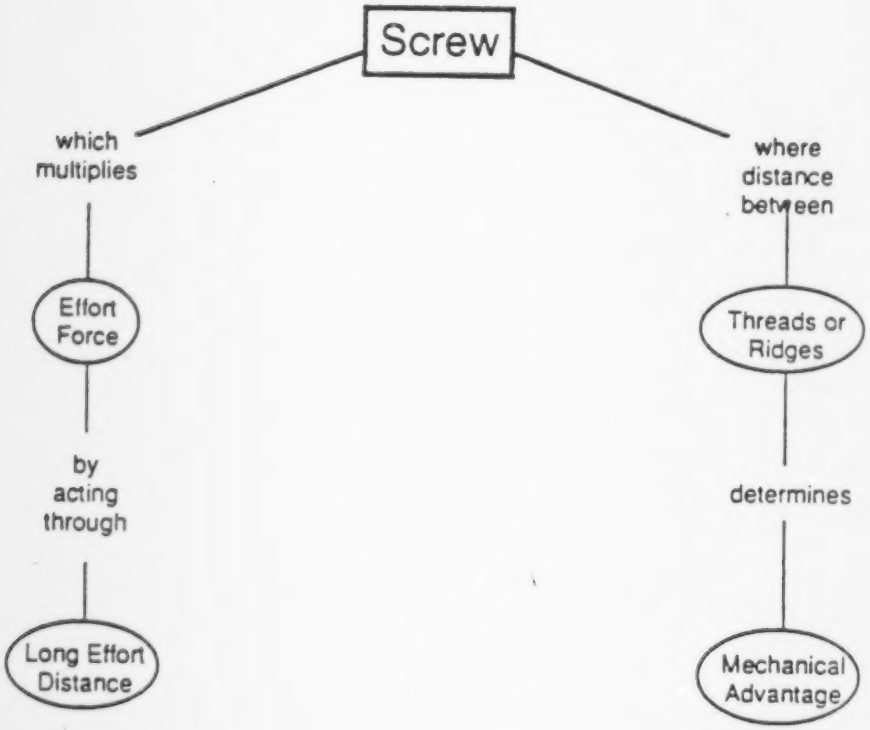
WORK AND SIMPLE MACHINES



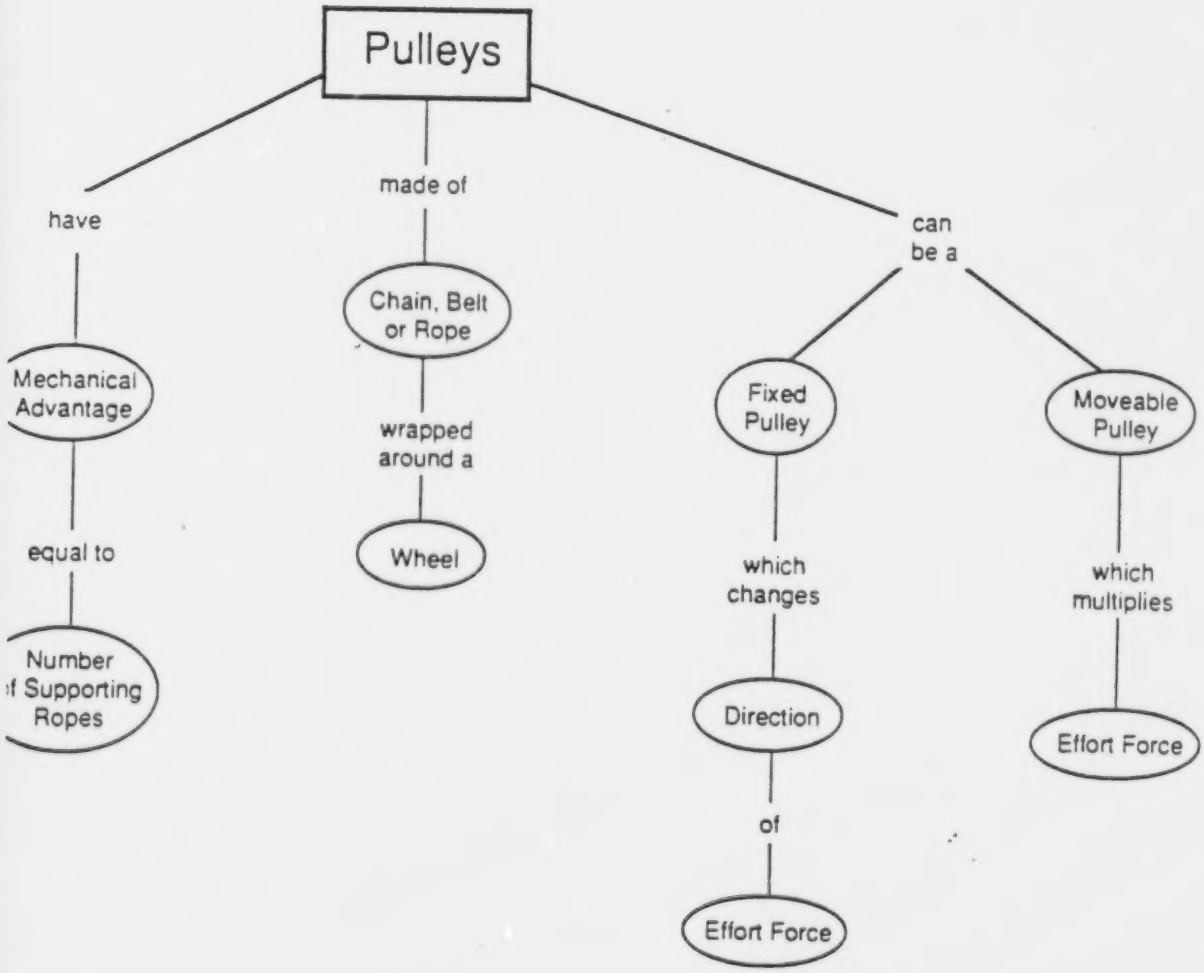
ategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377.



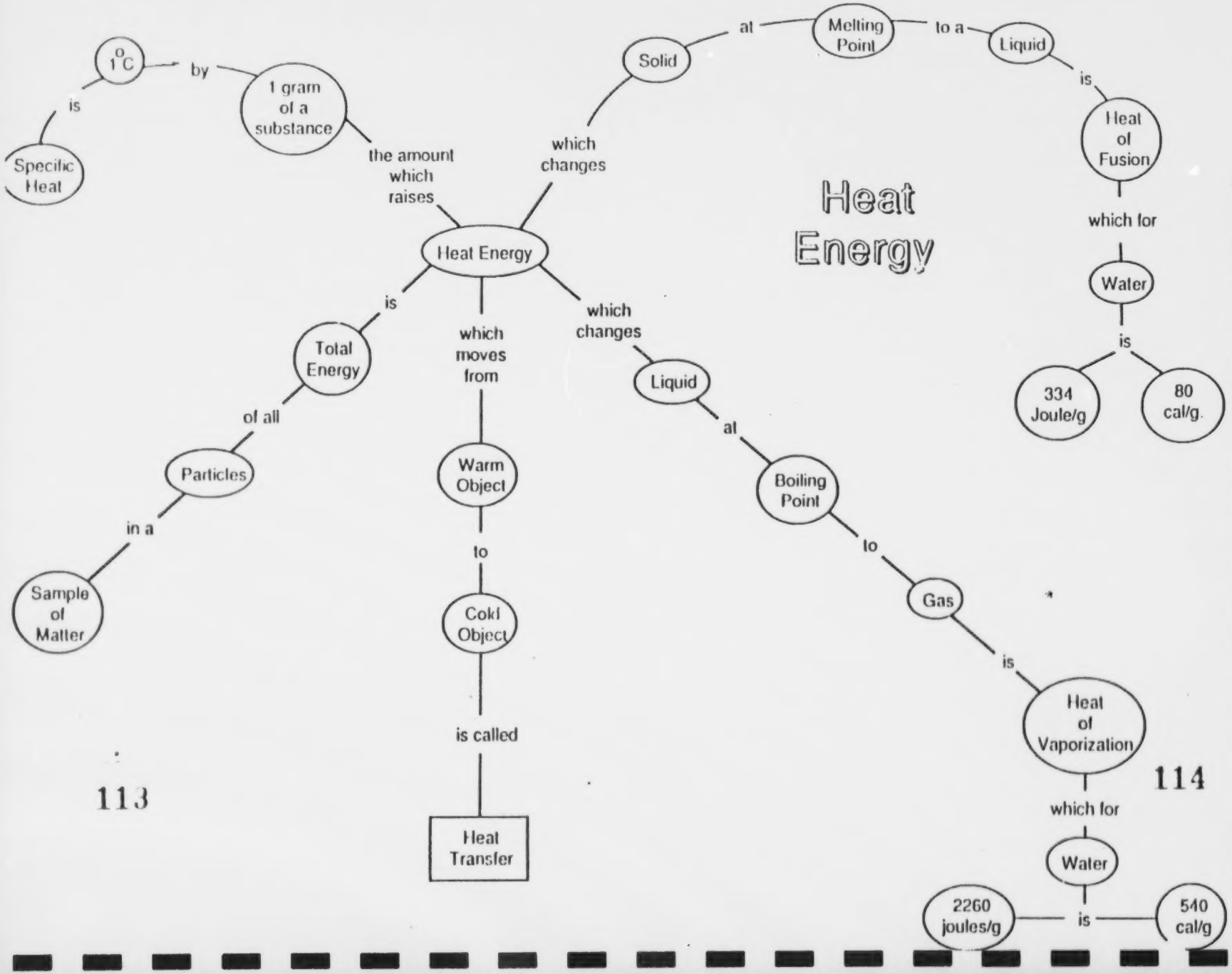
Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377.



tegies for Teaching Physical Science Facilitator's Manuel.
Science and Mathematics Education



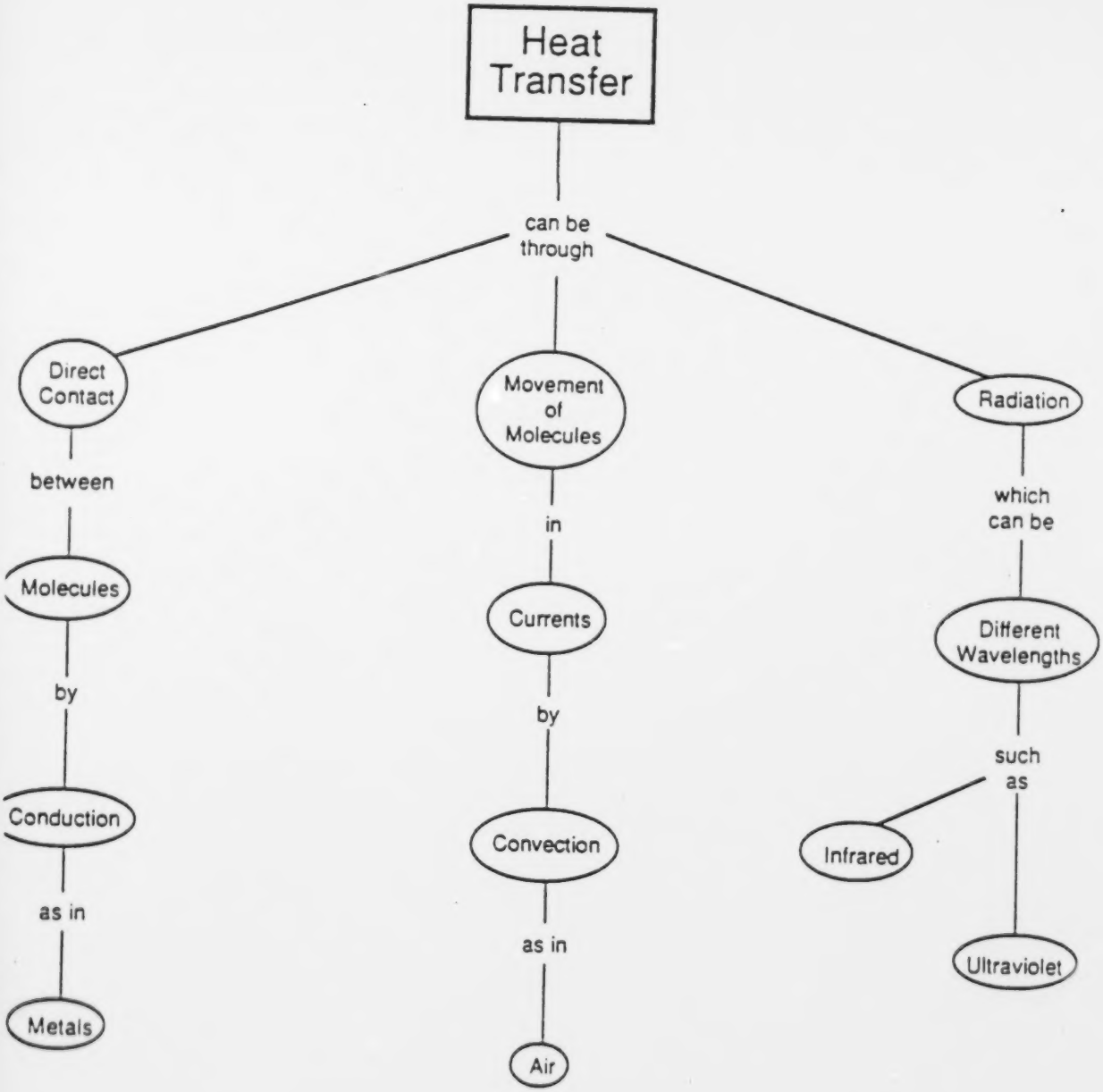
Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377



113

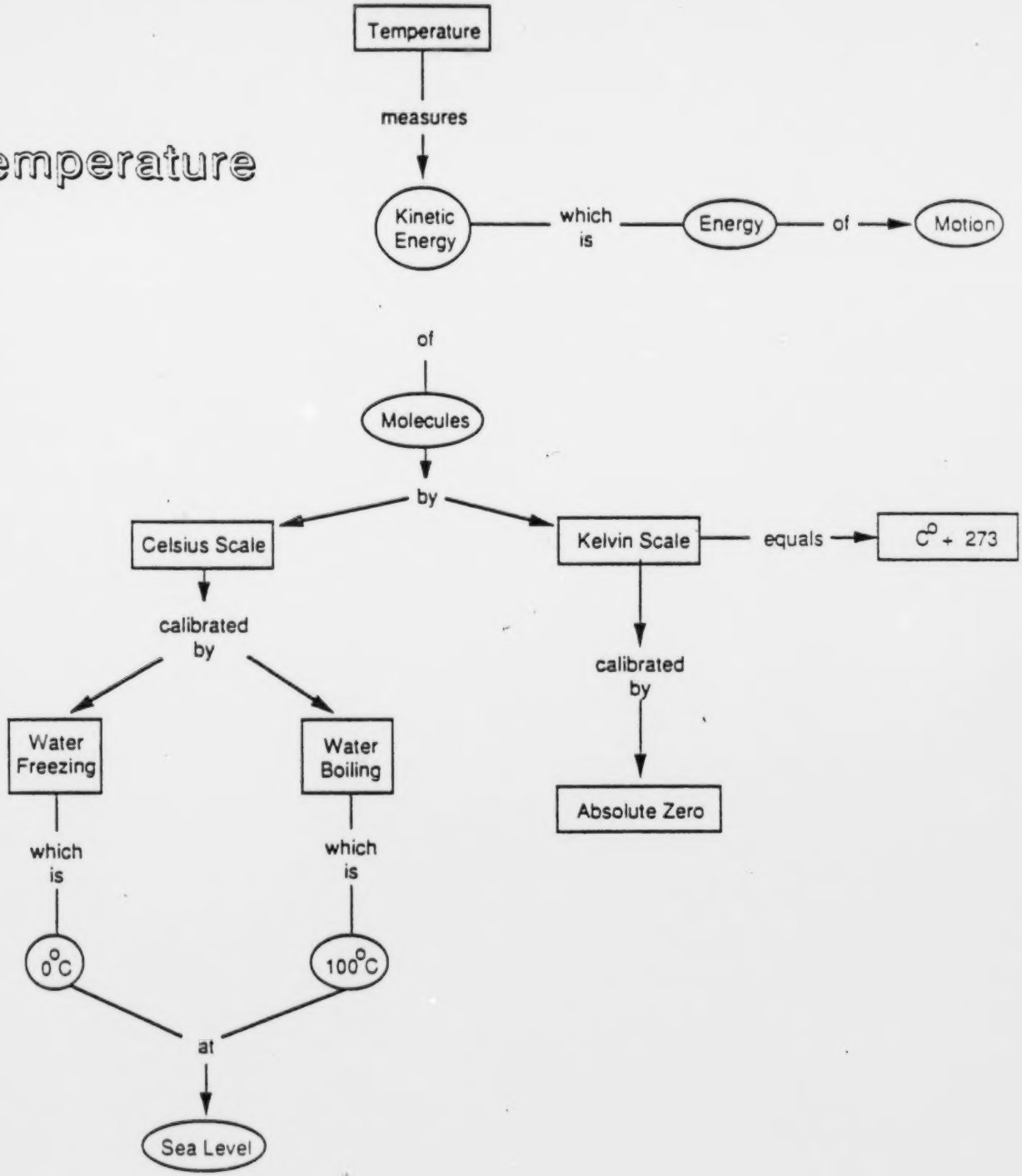
114

Strategies for Teaching Physical Science Facilitator's Manual.
Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone



Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377.

Temperature



ategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone

MAGNETISM

Magnetism is the attraction or repulsion that one material exerts on another. This is due to the arrangement of electrons in a magnetic material such as cobalt, nickel, iron, and alloys of these metals, or a naturally occurring magnetic material such as lodestone. Magnetic forces are strongest at the magnet's north and south poles . The region surrounding a magnet in which the magnetic forces can act is called a magnetic field. The Earth itself is a magnet surrounded by a magnetic field that is strongest near the north and south magnetic poles. The Earth exerts a magnetic force on compasses and the difference in location between the geographic and magnetic poles causes an error in the compass called magnetic variation which changes as one's position on the Earth changes.

The spin of an atom's electrons is primarily responsible for magnetism, and the region where the atoms in a magnetic material are grouped is called a magnetic domain. The behavior caused by the action of the domains leads to the law of magnets: "Like poles repel; unlike poles attract".

Magnetism and electricity can be combined through the concept of electromagnetism. Whenever an electric current flows through a wire a magnetic field is produced. The strength of the magnetic field present varies directly with the magnitude of the current flowing in the wire. This phenomenon was discovered by Hans Christian Oersted in 1820. In 1831, Michael Faraday discovered that magnetism can also be used to produce electricity through a process called electromagnetic induction. Whenever a wire is moved at right angles across magnetic lines of force an electric current is produced. The most important application of this concept is in the use of generators to produce electricity. Electromagnetism and electromagnetic induction are combined in the operation of transformers. These devices use two coils of insulated wire wrapped around the same iron core. One of these is the primary coil and the other is the secondary coil. If there are more loops in the secondary coil than in the primary, more voltage is produced and this is a step-up transformer. If there are more loops in the primary coil, then less voltage is produced and this is a step-down transformer.

egies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377.

ELECTRICITY

Electricity is the energy associated with the flow of electrons from one place to another. Materials that electrons flow through easily are called conductors, and those which slow down or stop the flow of electricity are called insulators. Metals are good conductors of electricity because the electrons are free moving and attracted to all of the nuclei at the same time. The flow of electrons is called electric current, and it is measured in units called amperes and with instruments such as ammeters and galvanometers. Opposition to a flow of electricity is called resistance, and it is measured in units called ohms. The potential energy or the amount of energy available to flow along a path is called voltage, and it is measured in units called volts and with an instrument called a voltmeter. All of the concepts about electric current may be combined through Ohm's law. This law states that current is equal to voltage divided by resistance. ($I = V/R$ or current = voltage/resistance or amperes = volts/ohms) In addition, there are two main types of electric currents, direct and alternating. In a direct current, which is produced by batteries and dry cells, the electrons flow in only one direction. In an alternating current, which is produced by fuel-powered generators, the electrons regularly reverse the direction of flow.

An electric circuit is the pathway used by an electric current. There are two main types of electric circuits, series and parallel. In a series circuit, there is only one pathway available for the current to reach the electric devices. Also in a series circuit, amperage remain the same while voltage is divided. In a parallel circuit, each electric device has its own pathway for the flow of electric current. With this type of circuit, voltage remains the same while amperage is divided among the electric devices or loads.

Electric power is the rate that an electric current provides energy or does work. It is calculated using the formula: power = voltage x current or $P = V \times I$. Power is calculated in units called watts, which are found by the formula: watts = volts x amperes. Most of the commercial use of power is calculated in units called kilowatts, or 1000 watts, and these are measured through devices called electric meters. To calculate the amount of energy used by a customer, the power company uses this formula: energy = power x time or $E = P \times t$. The unit used to measure this is the kilowatt-hour and electric bills are computed using a set monetary rate for each kilowatt-hour of energy used.

Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone

ELECTROMAGNETIC ENERGY

One of the most common forms of electromagnetic energy is light. Light is packets of energy called photons that travel along a transverse wave pattern. Light may travel through matter in one of three ways: it may pass through, it may bounce off, or it may be absorbed. Light passes through transparent materials, is reflected and absorbed but not passed through in opaque materials, and is transmitted some but also reflected and absorbed by translucent materials.

A beam of light is called a ray. One coming into a surface is called an incident ray, and one leaving a surface is called a reflected ray. Different types of images are produced when light is reflected off of various surfaces. A virtual image is formed by light rays that appear to converge but do not actually do so. An example of this is the image formed by a plane mirror. A real image, on the other hand, is formed by actual converging of the light rays. This is the only type of image that can be projected and an example is one type of image formed by a curved mirror. Virtual images are always erect and real images are always inverted.

Light may also be refracted or bent. Lenses are devices that do this, and there are two main types of lenses. One is a convex or converging lens. These are thicker in the middle than they are on the edges. The other type is the concave or diverging lens. These are thinner in the middle than they are on the edges. Nearsightedness is corrected with a concave lens and farsightedness is corrected with a convex lens.

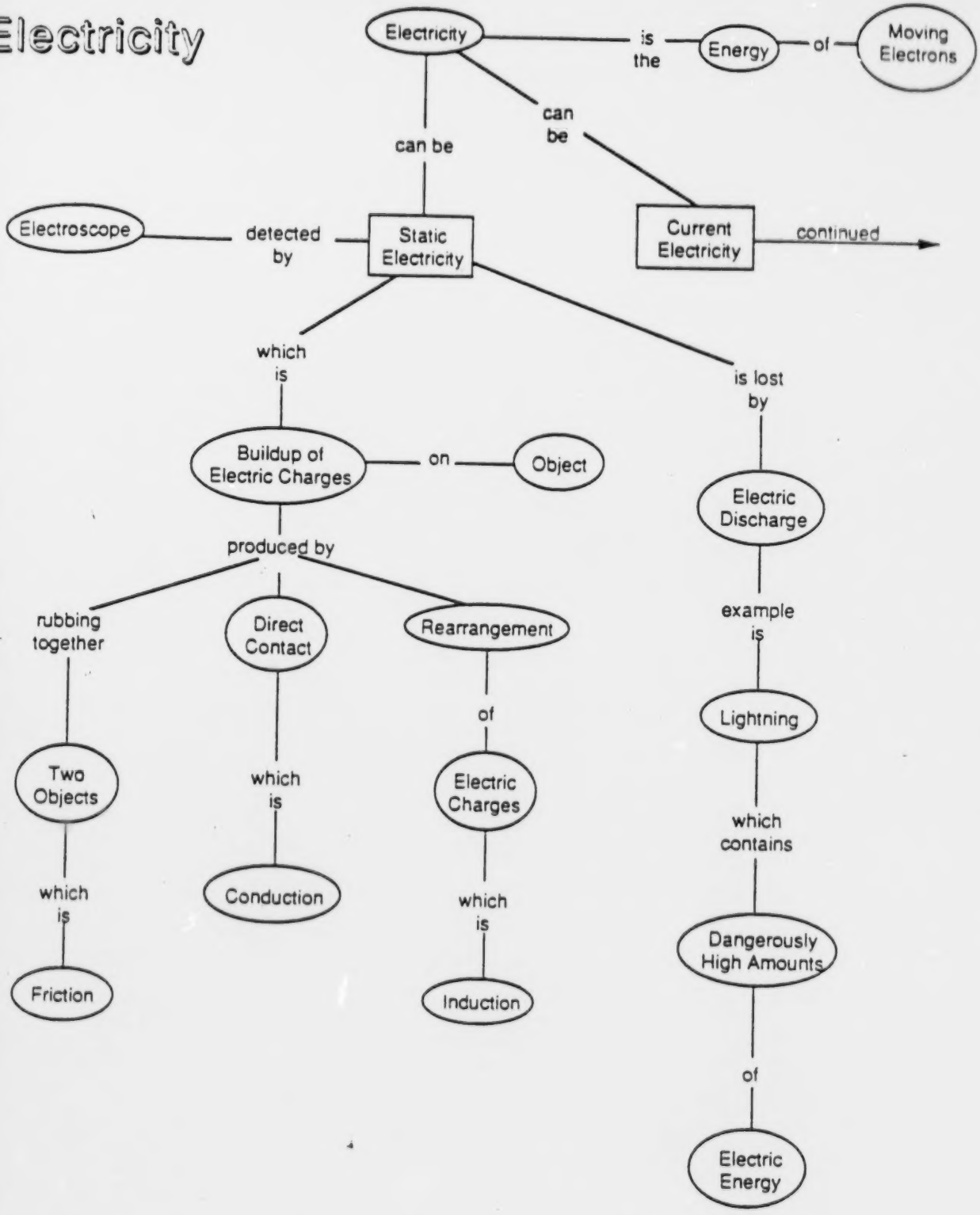
Light technology in the form of optical instruments such as cameras, microscopes, and telescopes has been greatly expanded in recent years. New developments include fiber optics, lasers and holography. An optical fiber is a long, thin flexible glass or plastic wire that can be used to transmit tremendous amounts of light energy. They are used in communication systems, medicine, and data processing. A laser is a device that produces coherent light of high intensity. Lasers are widely used in manufacturing, medicine, and for measuring long distances. Holography uses laser light to produce a three-dimensional image. One use of a hologram is to scan universal bar codes in grocery stores.

There are three primary colors of light. These are red, blue, and green. The secondary colors of light, magenta, cyan, and yellow, are the primary colors of pigment. White light may be refracted through a prism to show the visible light spectrum through a process called dispersion. The colors produced are red, orange, yellow, green, blue, indigo, and violet (ROY G. BIV). Red light is bent the least and violet bent the most. Red light travels faster in glass than does violet. As a result, it is bent less than violet light. Visible light is dispersed into the colors of the rainbow (red, orange, yellow, green, blue, indigo, and violet) as its component light waves travel at different speeds when passing through a prism or drop of water.

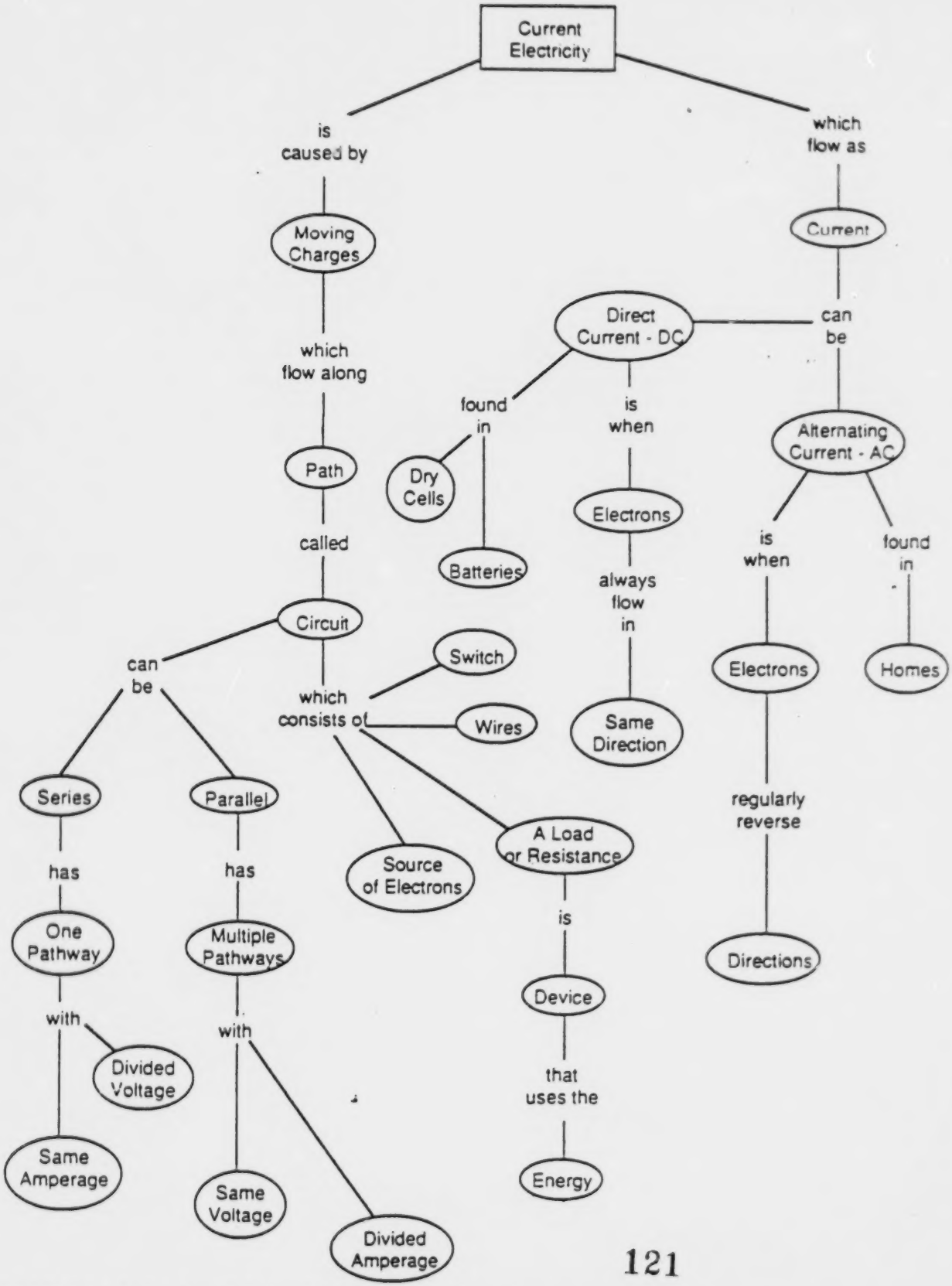
The visible light spectrum is only one small part of the complete electromagnetic spectrum. In order of decreasing wavelength the components of the electromagnetic spectrum are radio waves, microwave, infrared rays, visible light, ultraviolet rays, X-rays, and gamma rays.

trategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377.

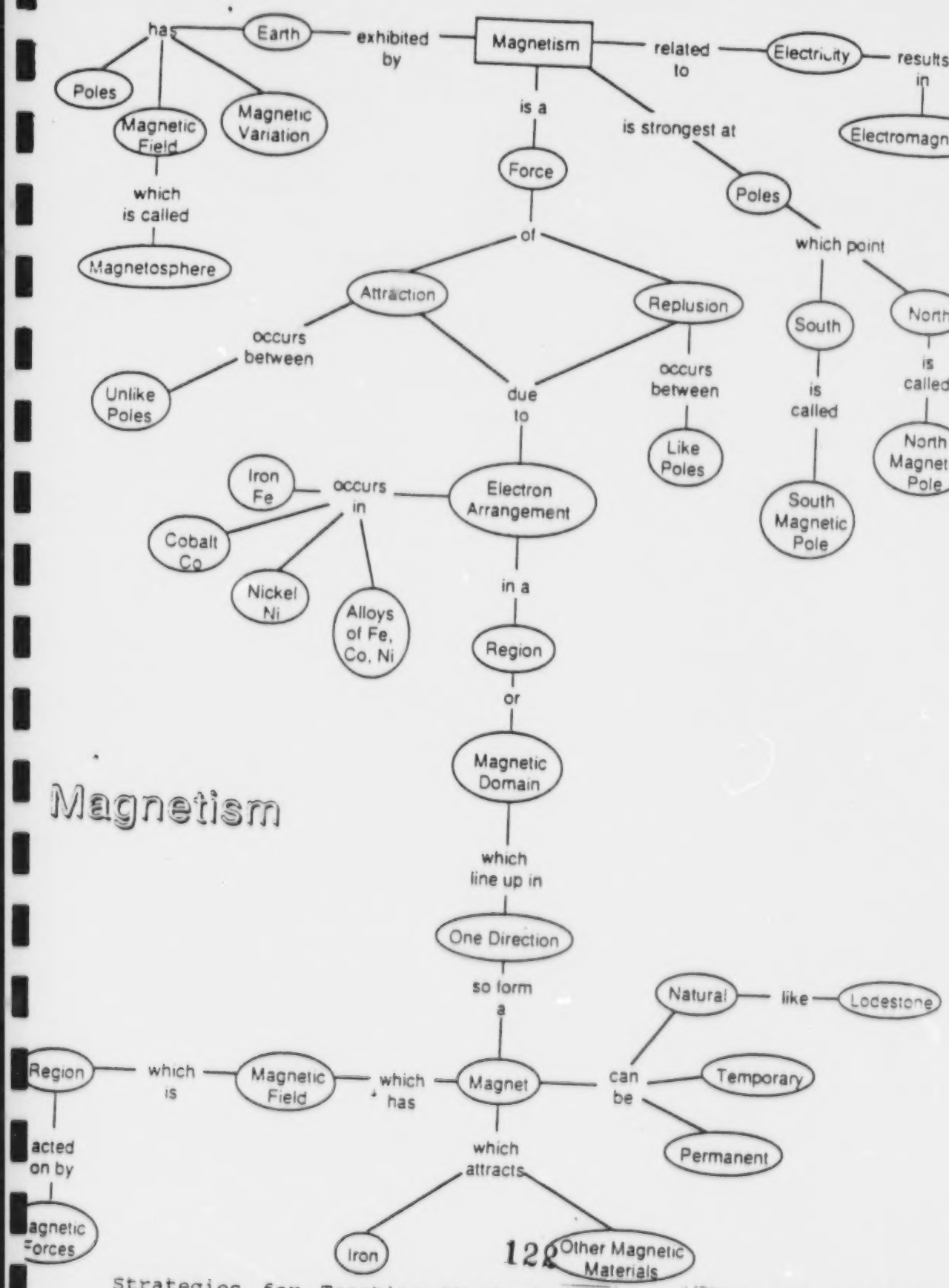
Electricity



Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone Number (806) 742-2377



trategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education, Texas Tech University, Lubbock, Texas. Phone



Strategies for Teaching Physical Science Facilitator's Manuel. Science and Mathematics Education Center. College of Education. Texas Tech

APPENDIX D

BEST COPY AVAILABLE

Problem Solving Strategies from QCC Objectives

K 24. Models, acts out, or uses a picture to solve simple problems.

1 45. Writes a sentence or sentences for a given story problem situation and solves, using models if necessary.

2 36. Employs problem solving strategies such as draw a picture, make a chart, and guess and check.

3 44. Employs problem solving strategies such as draw a picture, make a chart, graph or table, guess and check, look for a pattern, choose correct operation.

4 29. Employs problem solving strategies such as make a chart, graph or table, make an organized list, guess and check, make a simpler problem, look for a pattern, choose correct operation.

5 32. Selects and uses appropriate strategies for solving problems such as look for a pattern, guess and check, make an organized list, select an appropriate operation, simplify the problem, identify necessary information, work backwards.

6 32. Selects and uses appropriate problem-solving strategies such as look for a pattern, guess and check, make an organized list, select an appropriate operation, simplify the problem, work backwards, identify necessary information.

7 30. Selects and uses appropriate problem-solving strategies such as look for a pattern, guess and check, simplify the problem, identify necessary information, work backwards, draw a diagram or picture, write a mathematical sentence, use proportional reasoning.

8 26. Selects and uses appropriate problem-solving strategies such as look for a pattern, make an organized list or diagram, guess and check, identify necessary information, simplify the problem, work backwards, use logical and proportional reasoning.

Process Skills

A major goal of the Georgia science program is that it be "consistent with the nature and values of science which include its philosophy, methods of investigation and verification, conceptual organization, and accumulated knowledge." (Goal II)

One of the ways of achieving this goal is by emphasizing the thinking skills related to scientific inquiry. These are referred to as science process skills. They are the skills and procedures used by scientists in their work, and the components of what is commonly called the scientific method.

Several taxonomies of process skills exist. The one used here enumerates the process skills identified in the Quality Core Curriculum. These skills are to be used to investigate objects, phenomena, and events in the real world, and are best taught and practiced in conjunction with such investigations.

Sometimes it is useful to separate the process skills into two categories: basic and integrated. The basic process skills of observation, classification, communication, measurement, inference, and prediction provide a foundation for the more complex integrated process skills of identification and manipulation of variables, interpretation of data, formulation of operational definitions, formulation of models, designing and conducting experiments, formulation of hypotheses, and using space-time relationships. The integrated process skills rely on and are a blend of the basic process skills. Definitions and examples of the process skills follow. The number in parentheses is the lowest grade level at which that process skill is introduced into the Georgia Quality Core Curriculum.

Basic Process Skills

Observing (K) Using one or more of the senses to determine attributes, properties, similarities, differences, and changes in natural phenomena and objects. Observations can be made directly with the senses, or indirectly through the use of simple or complex instruments. Examples: Looking at a drop of food color as it diffuses in a jar of warm water. Determining the temperature, using either a hand or a thermometer.

Classifying (K) Organizing objects or events according to similarities or differences selected by the observer. Classification includes sorting elements into groups on the basis of common characteristics and ordering (sequencing) elements by relationships among the elements. Examples: Classifying leaves based on color, size, shape, number of lobes, etc. Using a taxonomic key to classify and identify trees.

Communicating (K) Presenting and explaining experiences with objects or events by means of oral or written descriptions, pictures, graphs, charts, maps, demonstrations, and/or other methods. Examples: Drawing a diagram of an experimental setup. Writing a lab report. Making a bar graph of the heights of students in the class. Presenting the results of an experiment orally to the class.

Measuring (1) Comparing an unknown quantity such as mass, length, or temperature with a known quantity such as a pupil-made standard or metric scale. Measuring includes the ability to estimate or to compare an object or event with a frame of reference. The process of measuring involves the use of instruments and the skills needed to use them effectively. Examples: Measuring the

length of an object by comparing it to a sugar cube's length. Measuring the same object with a metric ruler or a vernier caliper. Making indirect measurements of the thickness of a piece of paper by measuring the thickness of 200 sheets. Estimating the height of the classroom in various units.

Predicting (1) Suggesting what will occur in the future based on observations, measurements, and inferences about the relationships between or among observed variables. Predictions may be used to generalize that under a certain set of circumstances a certain outcome may be expected or they may be used to describe outcomes beyond the observed data. The accuracy of a prediction is closely related to the accuracy of the observations. Examples: Predicting (incorrectly) that heavy objects will fall faster than lighter objects based on the observation that a ball falls faster than a sheet of paper. Predicting (correctly) that heavy and light objects fall at the same rate after observing identical balls of different masses being dropped.

Inferring (K) Using observations and past experiences to reach a conclusion about a probable cause or about future outcomes. Inferring from a set of data may lead to several inconclusive inferences. Only further investigations and additional data may validate an inference. Example: Stating what an animal might eat, based on its teeth.

Integrated Process Skills

Using Space/Time Relationships (1) Perceiving and describing objects in terms of their space, motion, position, or location. This process includes the use of shapes, patterns, puzzles, cross sections, clocks, and compasses. Examples: Using a compass to identify the direction of travel. Describing changes in position using a map or grid. Reading a sundial.

Variables - Identifying (4) and Manipulating (5) Finding the variables of a system and selecting those that are to be held constant and the one that will be varied in order to carry out a proposed investigation. The variable that is changed by the investigator in an experiment is called the "manipulated variable" (also known as the independent variable). The variable that changes as a result is called the "responding variable" (also known as the dependent variable). Examples: In investigating what determines the rate of swing of a pendulum, the student identifies the weight of the pendulum and the length of the string as two variables that might matter. Weight is held constant, length (the manipulated variable) is changed, and the number of swings in thirty seconds (responding variable) is counted.

Interpreting Data (4) Identifying trends or patterns in sets of data. Patterns in the data may be used to establish generalizations, make predictions, and formulate hypotheses. Interpreting data involves organizing data, analyzing data, synthesizing data, and evaluating patterns in the data. Examples: Student makes a data table comparing length of string and number of pendulum swings. Student notes that as the length of the string increases, the number of swings decreases, and may note that longer string means slower swing.

Defining Operationally (5) Defining objects in the context of a common experience, telling one what to do to or with the object and what to observe as a result of the action. Examples: Defining "tall sixth grader" as a student in the sixth grade whose height is greater than 70 inches. Defining "period of

a pendulum" as the time required for a pendulum to swing (which can be found by dividing 30 by the number of back and forth swings in 30 seconds).

Formulating Models (5) Describing or constructing physical, verbal, mental, or mathematical explanations of systems and interrelated phenomena that cannot be observed directly. Models may be used in predicting outcomes of planned investigations. Examples: Building a model of a cell using a plastic bag for the cell wall, gelatin dessert for the cytoplasm, and batteries for the mitochondria. Describing the behavior of gasses as similar to collisions between billiard balls.

Constructing Hypotheses (5) Formulating generalizations that include all objects or events of the same class. A hypothesis is a "guess" about the relationship between variables. Before any sensible investigating or experimenting is done, a hypothesis is usually stated which expresses the investigator's guess as to the effect of the manipulated variable on the responding variable. The hypothesis must be tested if its credibility is to be established. Example: In a paper airplane contest, guessing that increasing the total wing area will increase the distance the airplane flies.

Experimenting (5) Designing and implementing procedures to obtain reliable information about interrelationships between objects and events. Examples: Designing an experiment to test the relationship between wing area and distance flown, including such skills as operationally defining wing area and distance flown, controlling variables such as the size of the paper used to construct airplanes and the placement of stabilizer weights, the construction of data tables and the measurement of distance flown.

Teachers should not assume that the teaching of basic process skills ends in the primary grades. The development of more sophisticated techniques for measurement, especially of large and small quantities, continues to be a current research topic. The Georgia mathematics curriculum provides further definitions of the progression expected in measurement skills. Classification systems, siuch as taxonomic keys, become increasingly complex.

The integrated process skills are also not necessarily taught in a sequential fashion. These must be taught in context, as they are best used when students are actively engaged in scientific investigation. It is possible to teach science skills (like how to read a hydrometer) in isolation, and science vocabulary (like peristalsis) without engaging in activity. It is not possible to develop the integrated process skills without a hands-on/minds-on program.

The Board of Directors of the National Science Teachers Association, in its Position Statement on Laboratory Science adopted January, 1990, describes the relationship between laboratory science and process skills as follows:

> The inquisitive spirit of science is assimilated by students who participate in meaningful laboratory activities. The laboratory is a vital environment in which science is experienced. ...Problem solving abilities are refined in the context of laboratory inquiry. Laboratory activities develop a wide variety of investigative, organizational, creative, and communicative skills...Laboratory activities enhance student performance in the following domains:
>
> **Process skills**: observing, measuring, and manipulating physical objects.
> **Analytical skills**: reasoning, deduction, critical thinking
> **Communication skills**: organizing information, writing
> **Conceptualization** of scientific phenomena.

At the middle level, this same NSTA position statement recommends that a minimum of 80 percent of the science instruction time be spent on laboratory related experience. Such experience includes prelab instruction in relevant concepts, hands-on activities by students, and post lab communication and analysis. Time spent on laboratory and process skill development also needs to be reflected in the assessment process.

Summary

During science lessons, process skills should be both taught and used. Depending on the purpose of the lesson, the lesson plan types will vary. Sometimes the purpose of the lesson will be the development of the process skill, as, for example, when a child is learning to measure using a new piece of equipment. In other situations, the purpose of the lesson will be inquiry, information acquisition, or concept attainment, during which the use of the process skill is needed. Process skills are the life skills that carry over from science when the facts are forgotten.

Math and Measurement Skill Sequencing
Georgia Quality Core Curriculum
Prepared by Susan Gannaway and Rosalie Jensen, North Georgia College

rade /Topic omputation	Length	Area/ Volume	Capacity	Temp./ Time	Mass	Data Analysis
indergarten ounts to 10 ractions: ½	Measures by counting non-standard objects; Compares and describes length; Orders objects from small to large					Constructs and interprets graphs with objects or pictures
irst lace value: 0; ounts to 9; ractions: /2, 1/4, /3 ums to 18	Describes and orders using non-standard units; Measures to inch or cm		Compares, using more or less	Selects units (minutes, hours, days, weeks); Calendar units: minutes, hour, day, week; Clock measures time; Tell time to hour and half hour	Compares using heavier or lighter	Constructs graphs using objects or squares; Reads bar graphs and picto-graphs
econd lace value: 00; ounts to 99; ome ddition and ubtraction acts to 18	New units: foot, meter; Measures length to inch, cm; Estimates length		Units: cup, quart, liter; Compares, using non-standard units	Knows thermometer measures temperature Tells time to 5 minutes	Units: kg, pound; Compares, using non-standard units	Constructs and interprets bar graphs and picto-graphs using whole unit data

pic ion	Length	Area/ Volume	Capacity	Temp./ Time	Mass	Data Analysis
ue: icts s 3 les igit	New units; km, yard, mile; Measures length using appropriate instruments	Locates points on map or grid; Uses concrete materials to find perimeter: Finds perimeter by adding numbers; Uses squares or tiles to find area and cubes to find volume	Units: liter, pint, quart, gallon, cup; Measures capacity using appro-priate instru-ments	Units:, °C. °F; Measures temperature using appropriate instruments Units: minutes through years; Tells time to five minutes; Interprets calendars	Units: gram, kilogram, pound, ounce; Measures weight/ mass using appropriate instruments	Organizes data in charts and tables; Constructs bar graphs and picto-graphs; Interprets data in tables and graphs
lue nting 99; o ten ed; es r in e, al mal	Same units; Measures to nearest half inch and nearer centimeter	same as third	same as third	Tells time to minutes	same as third	Organizes data in charts and tables; Constructs bar graphs and picto-graphs; Interprets data in tables and graphs

ıde /Topic ıputation	Length	Area/ Volume	Capacity	Temp./ Time	Mass	Data Analysis
fth ıce value l counting millions; ls, ›tracts, .tiplies; ·ides; :s .culators; ls and ›tracts ·imals ›ugh dredths	Selects appropriate units; Units: add millimeter; Measures to quarter inch and millimeter; Predicts; Measures using strategies like walking off and rough computation	Selects appro-priate units (squares, and cubes); Develops procedures to find the area and volume of various kinds of figures	same	Tells time to seconds	same	Collects and organizes data; Constructs bar graphs and picto-graphs; Interprets and draws conclu-sions from tables and graphs
th ction, imals, cents; forms versions metric tomary tems ns a portion two equal ions ers often	Measures angles, Find perimeter	Uses formulas to find area and volume, parallelo-gram, triangle, rectan-gular prism	Units: add fluid ounce and milliliter	Finds elapsed time	Units: add tons	Collects and organizes data; Constructs tables, picto-graphs and bar, circle, and line graphs; Makes mean predic-tions based on data; Finds mean, median and range

pic on	Length	Area/ Volume	Capacity	Temp./ Time	Mass	Data Analysis
r s ical or term n	Same as sixth Also include perimeter and circum-ference	Applies formulas for area, volume and circum-ference		Uses propor-tions to represent constant rate		Collects and organizes data; Constructs frequency distri-butions, tables, and bar, line and circle graphs; Interprets data in frequency distribu-tions, tables and graphs and makes predic-tions; Finds mean, median, mode, and range
s t oot c on nt p		Applies formulas including Pythag-orean theorem and surface area formulas		same as grade 7		same as grade 7

Gannaway and Rosalie S. Jensen, North Georgia College, December, 1993

APPENDIX E

BEST COPY AVAILABLE

Physics 460/Math 310--Spring, 1993
Teaching Assignment, Long Branch School

Grade 3 12:30-1:15	
Classroom teacher--Abernathy-25 Gunter, Jackson, Thomas, Stone	Plans to Jensen
Classroom teacher--Hammond-24 Pinion, Dills, Rinehardt, Fowler	Jensen
Classroom teacher--Jones -13 Collins, Heath	Gannaway
Classroom Teacher--Mahan-24 Towner, Lockhart, Blackmon	Gannaway
Grade 4 1:10-1:45	
Classroom Teacher--McClure-26 Mathis, Berson, Weston	Jensen
Classroom Teacher--Mueller-25 Brooks, Conley, Convard	Jensen
Classroom Teacher--Stringer-25 Crumley, Deegan, Sudderth, Walker	Gannaway
Classroom Teacher--Taylor-25 Dodd, Garrett, Johnson,	Gannaway
Grade 5	
Classroom Teacher--Brookshire-21 Rowan, Shook, Cox	Jensen
Classroom Teacher--Cook-21 Gaines, Howell, Mathison	Gannaway
Classroom Teacher--Greenway-19 Tomlin, Wallace, Wilson	Jensen
Classroom Teacher--Norris-21 Winberg, Lattanzi, Bennett	Gannaway

Information for Long Branch Elementary Field Experience

Date: May 10-14, 1993
Location: Long Branch Elementary School, Highway 52 E (approximately 6 miles from campus--allow 10 minutes)
Time: 3rd grade 12:30-1:15
4th grade 1:00-1:45
5th grade 1:45-2:30

This is the week of CBA testing, so the students will have been involved in testing during the morning. Third and fourth grades will be just getting back from lunch when you come in. Fifth grade has only recess after you leave.

You will work with a group of about eight students. Each classroom will include 3 or 4 NGC students. The coordinator for each classroom is the person whose birthday comes last in the year. The materials manager is the person whose birthday comes first. The remaining team member is the collector/distributor. The collector/distributor is responsible for the group's paperwork. The coordinator is responsible for contacting the teacher and arranging observation time. The materials manager is responsible for obtaining and returning any materials checked out from Dr. Gannaway or the school.

All of the students working in one classroom will do joint planning but prepare individual lesson plans. You do not have to be teaching the same plan on the same day, but over the course of the week, all of the students in your class should have the same experiences. In some instances, it will be convenient to rotate activities among groups in a classroom, in order to maximize effective use of space and equipment.

The topic for the week for all classes will be metric measurement and estimation of length, mass, area and volume. You are being supplied with some suggested activities which you may use or adapt. Be sure to look at the grade level objectives to decide how to adapt the materials.

You are responsible for obtaining all of the equipment needed to teach your activities, and for all of the photocopying needed for your class. Neither the education department nor the elementary school will do that photocopying for you. ABSOLUTELY do not ask at the school.

Dr. Gannaway will help you borrow or obtain necessary equipment. All equipment borrowed from her must be returned to room 330 on Friday afternoon.

Each student needs to find about an hour to observe the teacher and the class in which you will be working prior to developing you plans. Give your coordinator some suggested dates and times for observation, and let her make those arrangements for you.

Preliminary lesson plans for the first two days are due on April 28. You will not receive a grade on the preliminary lesson plans, but failure to turn them in on time WILL result in 5 points being deducted from your final lesson plan evaluation. The purpose in turning in the plans is to allow Drs. Gannaway and Jensen to give you some advance feedback on your plans (formative evaluation). We will make comments and suggestions on the plan. Also due at that time is a calendar for all five days. See the attached list for the teacher who should receive the plans.

Use the standard NGC lesson plan forms. Reference your lesson to OCC objectives.

Your classroom teacher or the Long Branch assistant principal and one of the instructors will observe you at least once during the week. Since half of the grade for this experience depends on classroom performance, those observations are important. Be aware that in order for each of us to see twenty people in five days, we must observe a minimum of four students a day.

Absences are an absolute disaster during this experience. Other students in your classroom do not have extra materials, etc, and students still have to be accomodated. Your grade will be reduced by 20% for each day you are absent without a doctors excuse. Make sure that you have eachother's phone numbers in the event of an emergency.

Lesson Plans
Math 310 Physics 460

Name of Student _____

Name of Teacher _____

Lesson ____ of 5 to be taught on _____

Objectives:
1.
2.
3.

Time	Objective Number	Activity	Materials	Evaluation

Lesson Plan Preliminary Evaluation

Objectives

Reflects objective rather than activity

Seldom | Usually | Always

Consistent with QCC

Unclear | Usually | Always

Measurable objective

Seldom | Usually | Always

Time

Alloted time estimate

Missing | Sometimes unrealistic | Looks good

Procedure

Degree of detail in plans

Inadequate | Adequate | Complete

Sequencing

One or more prerequisites out of sequence | Appropriate

Student management strategies

Lacking in plans | Insufficient detail /unrealistic | Present/workable

Learning cycle compatibility

Begins too frequently with explanation | Consistent when appropriate

Questioning strategies

Only lists topics to be discussed | Lists questions - mostly close ended | Questions are listed and varied

Measurement and mathematical skills taught

Plans show use but not instruction | Skills are assumed that students may not have | Skills needed and not possessed are taught

Materials

List complete

Inadequate | Satisfactory | Good

Copies of student/teacher written materials present

No | Several needed items missing | All present except those given out in class

Evaluation

Evidence of formative evaluation

Absent | Implied | Present

Checklists present for teacher observation

No | Sometimes | Yes

Performance tasks identified

No | Sometimes | Yes

Plans suggest that teacher will be able to identify whether student has achieved objective

Doubtful | Perhaps | Probable

Lesson Plan Final Evaluation

_____ _____

Quarter Student Name

_____	**Objectives** Consistent with QCC at grade level Measurable	3 points
_____	**Procedures** Time indicated for each part Directions for activities clear Degree of detail adequate Instruction on concepts/skills provided Activities consistent with objectives Appropriately sequenced Student management strategies clear Questioning strategies varied	8 points
_____	**Content** Mathematics, science, and measurement content accurate	3 points
_____	**Materials** Materials list provided for each lesson Copies of written materials provided	2 points
_____	**Evaluation** Formative evaluation described Performance tasks evaluated Checklists provided Evaluation consistent with objectives	4 points
_____	**Reflection Log** Copy of log for each lesson provided	2 point
_____	**Mechanics** Grammatical construction acceptable Spelling and punctuation acceptable Materials have professional appearance	3 points
_____	**Total Points**	25 points

Reflection Log

Math 310 Physics 460

Teacher's Name _____
Course _____ Date _____
Purpose of Lesson:

Answer the following questions about each lesson that you taught.

What was done:

How it worked:

One successful aspect of the lesson:

Why did this part go well? What do I know about teaching and learning that might explain why it worked? What conditions were operating that might explain it?

One less successful aspect of the lesson:

Why did this part not go well? What do I know about teaching and learning that might explain it? What conditions were operating that might explain it?

Pasch, Marvin, et al. (1991) *Teaching as Decision Making*. New York: Longman. p. 153.

Student Evaluation
Math 310 Physics 460

Note to Student: Fill out top portion of this form and give the entire form to your classroom teacher on the first day of your field experience.

Student's Name _____

Program (please circle one) ECE Middle Spec Ed Class: Soph Jr Sr

Prior classroom experience:

_____ Kindergarten practicum
_____ Tutoring program
_____ Student teaching
_____ In or already had block
_____ Took classroom management
_____ Work experience, parapro-, etc.

Days observed (please circle) M T W Th F

Please circle the appropriate response:

Arrives on time	Y	N
Has necessary materials	Y	N
Learns student names	Y	N
Uses good spoken English	Y	N
Teaches the full 45 minutes	Y	N
Has appropriate appearance	Y	N

Considering the student's class and prior experience, rate the student's performance on a scale of 1 to 5. 1 means not acceptable; 2, poor; 3, adequate; 4, good; 5, excellent.

Treats students with respect	1	2	3	4	5
Manages student behavior	1	2	3	4	5
Uses manipulatives effectively	1	2	3	4	5
Asks questions effectively	1	2	3	4	5
Identifies student's current skill level	1	2	3	4	5
Matches instruction to student skills	1	2	3	4	5
Provides instruction on science content	1	2	3	4	5
Provides instruction on measurement	1	2	3	4	5
Provides instruction on mathematics content	1	2	3	4	5
Creates and maintains interest	1	2	3	4	5
Has accurate knowledge of content	1	2	3	4	5
Assesses achievement of objectives	1	2	3	4	5

Identify an area of strength:

Identify an area in which improvement is needed:

Signature _____ Date _____

Evaluation of Teaching Performance

at _____ Elementary School

Name _____

Description	Evaluation		
Attendance	S	NI	U
Promptness	S	NI	U
Preparation of materials	S	NI	U
Use of materials	S	NI	U
Content knowledge	S	NI	U
Content development	S	NI	U
Appropriate level of instruction	S	NI	U
Delivery of instruction	S	NI	U
Rapport with students	S	NI	U
Questioning skills	S	NI	U
Management of activities	S	NI	U
Assessment skills	S	NI	U

Key: S = 2
NI = 1
U = 0
(add 1 for a total of 25)

Total Points _____

Typical Comments to Accompany

Evaluation of Teaching Performance

The following list has been developed over three quarters of observing students in the classroom. The comments are related to the descriptors listed on the form for evaluating teaching performance. A list of several comments is generated for each student and attached to the form. For a few students only positive comments are appropriate; however, most students receive both positive comments and indications of areas in which improvement should occur.

Positive Comments

Related to:	Comments:
Preparation	You are well prepared. You are well organized. Your group functioned well as a team.
Materials	You handle manipulatives effectively. You involve all students in using materials.
Content knowledge and delivery	You have good command of the content. Your instruction on _____was clear. You stress _____skills. Your review of previous content is good. You maintain eye contact well. You use misconceptions to teach.
Rapport with students	You have a friendly but firm manner. You create and maintain interest. You establish good rapport with students. You are enthusiastic and upbeat.
Management of activities and students	You keep students on task. You allow students to make appropriate decisions. You provide individual assistance without losing control of the group. You handle the flow of activities well, keeping students busy You give positive reinforcement for achievement.
Questioning	Your questioning strategies are good. You listen well to student questions and comments.
Assessment	You assess achievement of objectives throughout the lesson Your Reflection Log was thoughtful and insightful.

Improvement Needed

Related to:	Comments:
Preparation	Your lessons do not fill the entire time. Plan short extra activities, or allow time for assessment, review, or elaboration.
Materials	You must try the activity in advance with exactly the equipment to be used in class. You should let the students do more manipulating and measuring rather than watching you. You should put away objects that are not in use.
Content knowledge and delivery	You made content errors in _____. You assumed that students had _____ skills on which they needed instruction. You need to spend more time teaching _____ skills. You need to convey enthusiasm. You need to teach with more depth. Your students were capable of more than you expected of them.
Rapport with students	You need to be more assertive and upbeat.
Management of activities and students	Your time management could use refinement. You should improve your ability to keep students on task. You need to think about rules that could be established before you begin teaching so that students do not become management problems.
Questioning	You need to improve your questioning skills. You need to improve your listening skills. You need to be conscious of wait time.
Assessment	You need to improve your skills in assessment. Your Reflection Log is too brief, indicating a lack of metacognition.

APPENDIX F

BEST COPY AVAILABLE

Mathematics 310
Resource Unit

Each student will produce a resource unit for the level (K-4 or K-8) the student plans to teach. The resource unit must include:

1. At least one activity for each of four different objectives. Each activity must:
   a. State the QCC objective(s) for the activity
      (Example from grade 4: 4.8 - Determines pairs of numbers or missing element of pair when given a relation or rule.)
   b. Be no longer than one sheet, single spaced, except for student activity sheet or other attachment.
   c. Be written in standard English.
   d. Be written according to the format below and in a way that does not violate copyright laws.

Format

Title
QCC Objectives
Materials
Activity
Reference(s) used
Extension or variation (optional)
Student activity sheet (optional)

Note: The activity "Wipeout" is an example of an activity written in this format.

If a student activity sheet is part of the activity, a copy of the sheet must be included.

2. Four activities taken from at least three different resources. At least one activity **must be** from the *Arithmetic Teacher*.

Resource units are to be prepared in WordPerfect®, using the following method for naming the file:

____ ____ ____ G ____ ____. ____ ____ ____
(your initials) (level) (quarter)

Example: File name r s j G 4 f.a 93 indicates
Rosalie S. Jensen, grade 4, Fall 1993

The purpose of this assignment is to permit the student to demonstrate the ability to locate, select, and describe developmentally appropriate activities.

Mathematics 310
Resource Unit Evaluation Form

_____ Quarter

_____ Student Name

A. Meeting specifications (4 points)

_____ 1. Includes at least four activities

_____ 2. Activities address at least four objectives

_____ 3. Activities are in the appropriate format

_____ 4. At least three resources are used, including the *Arithmetic Teacher*

B. Quality of project (16 points)

_____ 1. Activities address objectives (3)

_____ 2. Directions are clear enough to permit someone else to perform the activity (4)

_____ 3. Mathematics concepts and skills are identified and described correctly (3)

_____ 4. Activities are appropriate to the age and grade level (2)

_____ 5. Grammatical constructions and spelling are correct (2)

_____ 6. The overall appearance of the project is professional (2)

_____ **Total Points**

Wipeout

Sample Activity

Objectives

Include full objectives from your grade level

Materials

Calculator for each player or pair of players

Activity

Someone acts as "caller." The caller instructs all players to enter into their calculators a whole number with a specific number of places. The size can vary according to the grade level of the students. After entering the number, each player records it on paper.

The caller directs the players to "wipe out" any digit of a particular value. For example, if the caller says "wipe out 3," a player with the number 23,784 could subtract 3000 to obtain 20,784 and a player with 35,037 could subtract 30,030 (or 30,000 and 30) to obtain 5,007. The caller keeps a written record of the digits as they are called.

The caller continues to specify digits to be eliminated until one player's display shows zero. That player calls "Wipeout" to indicate that he or she has won. The caller checks the original number against the digits called in order to validate the claim.

Variation

The caller specifies a certain number of digits to the right and left of the decimal point. Each player enters a decimal numeral with that many places in the whole number part and the decimal part. The game proceeds as described above.

Reference

English, L.D. (1991) From the file: Wipeout. *Arithmetic Teacher*, 39 (1) 60.

Physics 460
Resource Unit

Students will be assigned a topic on which to produce a resource unit. The following are requirements for the resource unit:

1. A listing of the QCC objectives for that topic must be included.
2. Include an annotated bibliography of teaching materials on the topic appropriate to those grades. The starting point for this bibliography should be *Science for Children: Resources for Teachers*, but students should also consult other sources.
3. Incorporate one activity to achieve each objective and a total of at least four activites. For example, students might be assigned the topic "Earth History" for grades K-3. The QCC contains six objectives on that topic for that grade level, so it will be necessary to find at least one good activity for four of these objectives.
4. Each activity should be:
    a. referenced correctly so that someone who wanted to find it could locate it in a library or order it.
    b. rewritten according to the format provided, and in a fashion that does not violate copyright laws
    c. no longer than one single spaced page.
5. The activities may not duplicate those in the textbook.
6. Students must use the following sources for at least one activity:
    Science and Children, *Science Scope*, or *The Science Teacher*
    Science Helper, K-8, or a science unit resource publication like *Naturescope* or the *TOPS* or *AIMS* series
    A general science activities sourcebook
    Other sources

Do not attempt to begin this assignment until we discuss it in class because we will describe how to find all of the above referenced materials.

The final resource unit may not exceed ten single spaced pages. Students will turn in two print copies and one copy as a Word Perfect¤ file. The Word Perfect¤ file should have the following filename:

XXXYYY.ZZZ

where XXX is the code for your topic, YYY is the quarter and year (F, W, or S, and year), and ZZ is either EC or MG depending on the grade level of the file. Your filename and your name should appear at the bottom of every page of your resource file.

The purpose of this assignment is to permit students to demonstrate the ability to find and select developmentally appropriate activities from a wide variety of sources.

Annotated Bibliography
Instructions and Format

A sample entry from an annotated bibliography follows. An annotated bibliography ontains a regular bibliographic citation followed by a brief paragraph describing the reference. ote that the description explains what kind of publication is being used, who the target audience what the publication contains, and how long it is. If the citation were from a journal, additional formation about the nature of the journal might be useful.

ld About Weather. *Ranger Rick's NatureScope*, Washington, DC: National Wildlife Federation, 1985.

Wild About Weather is an interdisciplinary guide to the causes, kinds, and impact of veather. Students from kindergarten to intermediate grades engage in classroom or playground periments, games, and simulations, as they investigate how weather happens and how it affects earth and its inhabitants. The 30 well-organized lesson plans are supplemented by student ctivity sheets and detailed background information. An appendix contains suggestions for aluation and many useful resources.

Grade(s): K, 1,2,3,4,5,6,7
pplies: Materials available locally.
uide: $6.00

Resource Unit Evaluation Form
Physics 460

Name of Student _____

Possible Points		Your Score
	Does the project meet specifications:	
3	a. contains objective list	_____
3	b. contains minimum of four activities	_____
3	c. contains an activity for each objective (up to 4)	_____
3	d. activities in appropriate format and all referenced	_____
3	e. activities do not duplicate those in science text	_____
15		
	Quality of project:	
5	a. activities address objectives	_____
3	b. process skills correctly identified	_____
2	c. objective for activitiy states objective rather than restating activity	_____
5	d. directions are clear enough to permit someone to perform the activity	_____
5	e. science concepts are identified/described correctly	_____
3	f. grammar and spelling are correct	_____
5	g. activities identified are age/grade appropriate	_____
2	h. annotated bibliography contains complete reference in an accepted bibliographic format	_____
2	i. annotations give an idea of both the audience for whom the reference is intended and the scope/nature of the publication	_____
3	j. the overall appearance of the project is professional	_____
35		
	Your total	_____
	Your score	_____

Note: Divide the total number of points by 2 to obtain the final score (based on a maximum score of 25)

Physical Science
Machines & Force

Sample Activity

Grade Level : 3 Gravity/Force

QCC # 8 (include full objective and include related math objectives)

Topic: Can we measure force?

Process:
Observing
Inferring
Predicting

Objective for Activity:

To measure the force to lift various objects
(This may extend beyond the QCC objective)

Materials:
cardboard strip (6 cm x 30 cm)
large rubber band
masking tape
string, pencil, paper
3 paper clips
5 small objects

Approximate cost: $2.00 - 5.00

Availability of materials: Readily available

Safety: Teacher supervision

Procedure:

1. Make a scale
   slip one end of the large rubber band into one paper clip
   attach the paper clip to one end of a heavy cardboard strip (6 cm x 30 cm)
   use masking tape to hold paper clip on the cardboard
   slip free end of rubber band into a second paper clip
2. Make a mark on cardboard where rubber band ends
3. Hook an object to the scale
4. Lift the object
5. Make a pencil mark on the cardboard to show how far rubber band stretches
6. Write the name of the object by the mark
7. Repeat steps 3, 4, 5, and 6 with all objects
8. Which object took the most force to lift?
9. Which object took the least force to lift?
10. Predict the force needed to lift 3 of the objects at one time
11. Test your predictions
12. Pull each object across the table with the scale
13. Compare these forces with those needed to lift the objects

APPENDIX G

BEST COPY AVAILABLE

MATHEMATICS 310

ng, 1993 TEST 1 Name _____

(15 points) **MULTIPLE CHOICE.** In front of each item write letter corresponding to the best answer.

1. If A = (0, 2, 4) and B = (0, 1, 3, 5), which is true?

   a. $A \subset B$
   b. $A \cup B$ has 6 elements
   c. $A \cap B = \{\ \}$
   c. $A \cup B$ has 7 elements

2. Which sequence is an arithmetic sequence?

   a. 1, 3, 6, 10, 15, 21, ...
   b. 6, 11, 16, 21, 26, 31...
   c. 3, 12, 48, 192, 768, ...
   d. 1, 10, 100, 1000, 10000, ...

3. Which statement is true?

   a. $4^0 = 0$
   b. $4 \div 0 = 0$
   c. $0 \div 0 = 0$
   d. $0 \div 4 = 0$

4. Evaluate: $10 + 10 \times 17 - 12 \div 4$

   a. 43
   b. 82
   c. 177
   d. 280

5. Evaluate: $(3^6 \times 3^2) \div 3^4$

   a. 27
   b. 81
   c. 243
   d. 6561

(16 points) **ABOUT SETS.**

1. Let U = {a, b, c, d, e, f, g, h}., A = {a, b, c}, B = {b, d, f, h}, and C = {c, e, g}. List the ents of each set. Use correct set notation.

   a. $A \cup B =$ _____

   b. $B \cap C =$ _____

2. **Using attribute pieces.** Let the universe be your set of 12 attribute pieces. Let S=(small pieces), L=(large pieces), R=(rectangles), WH=(white hexagons). **Use these sets in solving parts a, b, and c.**

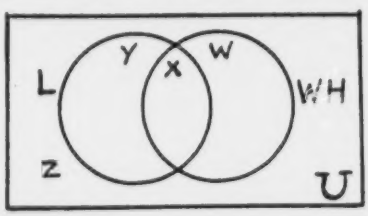
   a. Name all pairs of sets which are **disjoint.**

   _____

   b. List the elements which are in the **complement** of S ∪ R. Use correct **set notation.**

   _____

   c. There are 4 regions with labels **w, x, y,** and **z** in each Venn diagram below. In each region write the number corresponding to the number of elements if U = (attribute pieces).



C. (9 points) **TRUE OR FALSE.** Indicate whether the statement is true or false. Supply a <u>counterexample</u> for false statements.

_____ 1. Subtraction is commutative on the set of whole number.

_____ 2. Multiplication is associative on the set of whole numbers.

_____ 3. Addition is closed on the set of whole numbers less than 50.

D. (12 points) **PROPERTIES OF OPERATIONS.** Write one of these symbols in front of each statements: **A** (associative); **Cl** (closure); **Co** (commutative); **D** (distributive); **I** (identity)

____ 1. 45 + (13 + 25) = 45 + (25 + 13)

____ 2. 22 x 0 is a whole number.

____ 3. 28 x (14 + 36) = 28 x 14 + 28 x 36

___ 4. (14 + 8) + 22 = 14 + (8 + 22)

NOTE. **For all questions that follow the test provided to students includes space for work and explanations.**

(17 points) **USING TEACHING AIDS.** Explain through words and/or pictures how to develop each concept or skills. In each case the child should be the one manipulating the materials. Sets of materials (except attribute pieces) are on the cart. (Use the back of the page for additional space.)

1. Unifix Cubes. Assume that each child has some Unifix Cubes of two different colors. Explain how to develop the commutative property of addition using the Unifix Cubes.

2. Unifix Cubes or Base Blocks. Write a problem to show the concept of subtraction named. Explain how to solve your problem with Unifix Cubes or Base Blocks.

   a. take-away concept

      Problem:

      Solution:

   b. comparison concept

      Problem:

      Solution:

3. Base Blocks.

   a. Sketch the base blocks needed to solve the problem 14 x 23. Fill in the blank:
      14 x 23 = _____

   b. Explain how to use the base blocks to solve the problem 17 3 using the measurement concept of division.

(15 points) **ALGORITHMS, ESTIMATION, AND MENTAL COMPUTATION.**

1. Show the steps in your thinking process in solving each problem by the mental computation method listed.

   a. Use compatible numbers
      327 + 140 + 23 =

   b. Use equal products
      50 x 864 =

2. Show the steps in estimating each result using the estimation method listed.

   a. Use rounding
      1372 + 3821 - 1963

   b. Use front-end estimation
      1372 + 3821 - 1963

3. Solve the multiplication problem 27 x 56 by using partial products.

G. (15 points) **PROBLEM SOLVING STRATEIGES.** Use one strategy or several strategies from the following list to solve each problem: make a drawing, guess and check, make a table, solve a simpler problem, use a model, work backward, make an organized list. Solve the problem in the space provided, write your final solution in the blank, and tell which strategy (strategies) you used. **NOTE.** You may not use the same strategy for solving all four problems.

1. On the planet Tri, the Triceps hold a town meeting once a year. There is a pattern in the numbers of Triceps who have attended these meetings. Three Ticeps went to the first meeting. Six Triceps went to the second meeting, and ten Triceps attended the third meeting. Fifteen Triceps went to the fourth meeting, and 21 Triceps attended the fifth meeting. At what meeting will there be 210 Triceps?

   Solution. _____

   Strategies _____

2. This season Jose, an Oakwood Bees pitcher, struck out 27 more batters than he did last year. Last year Jose struck out 18 more batters than he did two years ago. Two years ago Jose struck out nine more batters than he did three years ago. Three years ago Jose struck out only nine batters. How many batters did he strike out in all during the four years?

   Solution. _____

   Strategies _____

3. Sharon and Ginny are playing a board game and collecting colored coins. There are three kinds of coins, worth $5, $20, and $50. Ginny has 138 coins worth $3150. How many coins of each value does Ginny have?

   Solution. _____

   Strategies. _____

MATHEMATICS 310

Spring, 1993 **TEST 2** Name _____

A. (18 points) **MULTIPLE CHOICE.** Write the letter corresponding to your choice in the blank.

___ 1. How many multiples of 6 are less than 35 and greater than 0?

a. 3 b. 4 c. 5 d. 6

___ 2. Which number is a factor of $2 \times 3 \times 5 \times 7$?

a. 12 b. 21 c. 24 d. 25

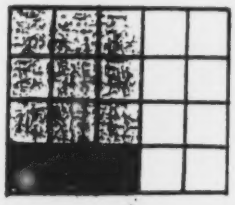
___ 3. Which problem could be solved by referring to the diagram?

a. $1/4 \times 3/5$

b. $1/5 \times 3/4$

c. $1/5 + 3/4$

d. $3/5 \div 1/4$



___ 4. Jenna is trying to determine whether 783 is a prime number. She begins by dividing by 2, 3, 5, 11, etc., in order. What is the largest prime number that she must divide into 783 if she has not found a smaller prime factor?

a. 19 b. 23 c. 29 d. 31

___ 5. Belita worked each problem as indicated. Find her error pattern and then solve the last problem using the same error pattern.

$$\begin{array}{r} \frac{2}{9} \\ -\ \frac{1}{5} \\ \hline \end{array} \qquad \begin{array}{r} \frac{7}{8} \\ -\ \frac{2}{3} \\ \hline \end{array} \qquad \begin{array}{r} \frac{3}{10} \\ -\ \frac{1}{7} \\ \hline \end{array} \qquad \begin{array}{r} \frac{5}{12} \\ -\ \frac{2}{7} \\ \hline \end{array}$$

a. $\frac{3}{12}$ b. $\frac{3}{5}$ c. $\frac{7}{19}$ d. 1

___ 6. Which number is closest to 5/16?

a. 3/8 b. 15/64 c. 1/4 d. 11/32

NOTE. **The test provided to students includes space for work and explanations.**

B. (12 points) **WRITE AN EXAMPLE**

1. Name an integer that is not a whole number. _____

2. Name a fraction between 5/7 and 6/7. _____

3. Name 2 whole numbers that are relatively prime._____

4. Name a 3-digit number that is divisible by 2 but is not divisible by 4. _____

C. (14 points) **FILL IN THE BLANK.** Follow the directions for each item. Use the space for your work.

1. Use divisility tests to write a digit in each blank so that the number in the first column is divisible by the number in the second column.

Number	**Is Divisible By**
34,5__1	9
5__7,391	11

2. Name the property of operations illustrated by each statement.

A - associative
Cl - closure
Co - commutative
D - Distributive
Id - identity element
In - inverse element

_____ a. 3 - 7 is an integer

_____ b. 1/3 + 1/4 = 1/4 + 1/3

_____ c. (-7) + 7 = 0

_____ d. (-3 + 8) x 10 = (-3) x 10 + 8 x 10

D. (23 points) **CONSTRUCTED ANSWER.** No credit will be given if you do not show your work on parts 2 through .

1. Find the GCF of 18 and 24 by writing the set of all factors of each number.

GCF (18, 24) = _____

Factors of 18: _____

Factors of 24: _____

2. Write the prime factorization of each number using either a tree diagram or short division.

   a. 90 = _____ b. 135 = _____

3. Use the prime factorization method to find the GCF of 90 and 135. GCF (90, 135) = _____

4. Find LCM (90, 135) by both methods.

   a. prime factorization

   LCM (90, 135) = _____

   b. formula that relates LCM to GCF

   LCM (90, 135) = _____

5. Find the solution for the problem. Write the answer in **simplest form**.

$$3\frac{3}{4} \times 2\frac{1}{3}$$

_____

E. (18 points) **TEACHING AIDS.** Explain through words and/or pictures how you would teach the concept or skill to students at an appropriate grade level.

1. **Use BLACK AND RED CHIPS** to respond to each item.

   a. Display the number -4 in four different ways

   b. Solve the problem 5 - (-2) = _____.
   Fill in the blank to indicate your final solution.

2. **Make and use a PAPER STRIP NUMBER LINE.**

   a. Let the peach colored strip serve as a model for 0 to 1 on the number line. Fold the strip to show all fractions from 0 through 1 which have denominators of 2, 3, 4, and 6. **Use the same process developed in class. Staple it to the back of this page.**

   b. Explain how to use the strip to introduce the concept of **equal fractions.** (Use specific examples.)

   c. Explain how to use the strip to find fractions that are in **simplest form.** (Use specific examples)

   d. Explain how to show students to add 1/2 and 1/3.

F. (16 points) **PROBLEM SOLVING STRATEGIES.** Use one or more of the strategies from this list to solve each problem: make a drawing, guess and check, make a table, solve a simpler problem, find a pattern, use a model, work backward, make an organized list, use properties of numbers. **NOTE.** You may not use the same strategy for solving all problems.

1. At Joe's Pizza Parlor, a slice of pizza is 1/12 of a whole pizza. At one point in time, Joe noted that there was 2/3 of a pizza left. A customer asked for 9 slices. Was Joe able to serve the customer without baking another pizza? Justify your answer.

   Solution. _____

   Strategies._____

2. Jennet got into an elevator to deliver mail in an office building. She went down 7 floors, up 5 floors, and down 9 floors. She was then on the third floor. Where did she get on the elevator?

   Solution. _____

   Strategies._____

3. Jane is planning a party at which she expects 16, 24, or 12 guests. She is unsure of the number of guests but wants to have available an equal number of hors d'oeuvres for each guest with none left over. She is on a budget and wants to order the minimum number that will serve the number of guests expected. How many should she order?

   Solution. _____

   Strategies._____

4. How many whole numbers greater than 0 and less than or equal to 300 are neither multiples of 2 nor 5?

   Solution. _____

   Strategies. _____

e_____

Test 1--Measurement
Physics 460, Fall 1992

YOUR NAME ON ALL PAGES OF THE TEST, BECAUSE THEY ARE SEPARATED
ING GRADING. Each numbered or lettered section is worth 3
nts.

ect the best answer and record it on the scantron sheet for the
llowing multiple choice questions

Measurement is-
a. always exact
b. always approximate
c. sometimes exact and sometimes approximate
d. exact only when the instrument is very refined
e. approximate only when the measurere is not careful

Measurement is-
a. comparison with a standard unit
b. naming by units
c. Describing a large quantity in terms of smaller quantities
d. finding the exact amount of something
e. none of the above

. Which of the following kinds of measure would be appropriate
r the capacity of a car trunk?
a. liner measure
b. weight measure
c. mass measure
d. square measure
d. cubic measure

The circumference of a circle is measured in
a. square units
b. cubic units
c. circular units
d. linear units
e. degrees

Which is the most appropriate unit for the weight of a football
ayer?
a. centigrams
b. grams
d. dekagrams
d. hectograms
e. kilograms

. The dimensions 2' x 3' x 1/2' most likely belong to
a. an unabridged dictionary
b. a rug
c. a garbage can
d. a doghouse
e. a suitcase

. Which of the following is not a fundamental unit of measure?
a. liter
b. meter
c. kilogram
d. second
e. degree Kelvin

Name_____

8. A measurement made on a scale divided into pounds has a greatest possible uncertainty of
   a. 1/2 pound b. 1/4 pound
   c. 1/8 pound d. 1 pound
   e. none of the above

9. Centigram is to gram as-
   a. milligram is to hectogram
   b. penny is to dollar
   c. kilometer is to dekameter
   d. one degree Farenheit is to 100 degrees Celsius
   e. none of the above.

10. The capacity of a silo can be found by multiplying
   a. the height by the diameter of the base
   b. the height by the squared radius of the base
   c. the height by the circumference of the base
   d. the height by the area of the base
   e. none of the above

11. 2.36 x 0.0005 is best reported as
   a. 0.001
   b. 0.011
   c. 0.0012
   d. 0.00118
   e. 0.001180

12. Which of the following has five significant digits
   a. 50300 b. 2.0346 c. .00005 d. 500.000

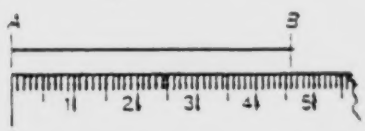
13. 45 centimeters is also
   a. 4.5 meters b. 0.45 meters c. 450 meters
   d. 4500 millimeters e. 45 meters

14. 542 ml could also be correctly expressed as
   a. 5.42 l b. 5.42 cm^3 c. 542,000 l d. 542 cm^3
   e. .542 cm^3

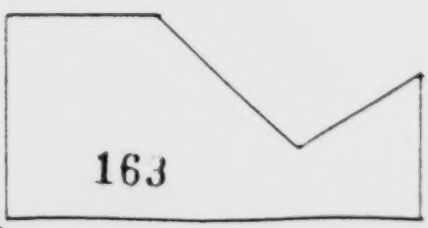
15. 4.21×10^{-2} cm is which of the following
   a. 421 cm b. 42100 cm c. 0.421 cm d. 0.0421 cm
   e. none of the above

Answer the remaining questions and problems on the test paper

16 Record the length of AB

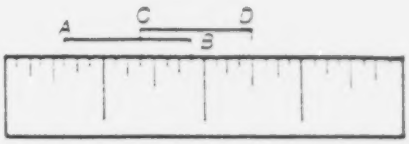


17. Estimate in square centimeters the area of the polygon shown.



the temperature
n the Celsius
eter.

19
Measure the line segments shown below. What is the difference in their length?



AB=_____
CD=_____
Difference =_____

. Write the measure below with the appropriate number of

plain how to determine the number of digits needed in a ement.

etric conversions:

. 8.12 g = _____mg

. 119 ml = _____l

. 3070 cm_3 = _____ m_3

. 10 micrometers = _____cm

ustomary conversions

. 4.25 lb. = _____oz

. .816 gal = _____qt

. 1 mile = _____in

onversions using conversion factors

. 7150 ml. = _____gal (1 l = 1.06 qt)

. 4.25 lb = _____ kilograms (454 grams = 1 lb)

a piece of irregularly shaped metal with a mass of 67.6 grams und to have a volume equal to 12.8 mL, determined by water cement. What is the density of the metal?

BEST COPY AVAILABLE

Name_____

25. a. Explain the difference between the terms "heavier" and "denser".

b. In New York they raise a variety of apples used in making pies. The name of this variety is "20 oz" because that's the typical size.

1. Give an operational definition of a "heavy" apple.

2. Considering your answer to #1 above, if you had a 32 oz. apple, would it be heavy? Would it be dense? How would you know?

You will be assigned to measure some objects. Put your answers below. Be sure to record with the correct number of digits for the measuring unit used.

26. Mass

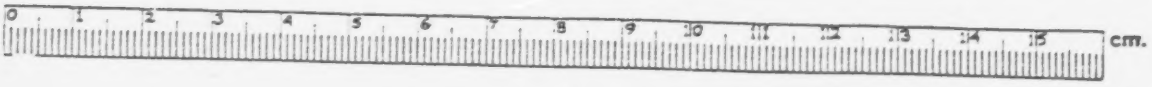
27. Surface area using a ruler

28. Surface area, using grid paper

29. Volume using a ruler

30. Amount of water in cylinder

31. Volume, using water displacement



Physics 460, Test 2
May 1993

---

r False.(3 each, 30 total)

ou observe on the dashboard of your car that you are traveling es per hour. That is your velocity.

ubbing alcohol is an example of a liquid that is more viscous ater.

ork is a vector quantity.

correct definition of mechanical advantage is D_e/D_r

riction is not a vector because it does not have a direction.

sing a simple machine reduces the amount of work done by the

an object is acted on by a force but does not move, no work ne.

en a car drives around the drill field at a uniform speed, it celerating.

A bearing of 120 degrees corresponds to the direction east.

A screw is a simple machine based on a lever.

ical questions:

Face the back wall of the classroom and determine the tion (bearing) in degrees from north.(3)

Turn the long side of your paper so it is parallel to the ows. Find the bearing of the arrow at the bottom (3)

rop an apple from the window of a moving car. Describe the n of that apple from the two frames of reference described w.

If you are standing beside the road as the car goes by ling to your left, how does the apple appear to move to (3)

If you are leaning out the window of the car as the apple is ed, how does the apple appear to move to you?(3)

Name_____

You will be provided with two simple or compound machines. Draw a diagram of the machine, labeling the simple machine(s) present. (3 each)

14. Identification of first machine:_____

Labeled diagram:

15. Identification of second machine _____

Labeled diagram:

16. Identification of third machine _____

Labeled diagram:

Distinguish between the following terms:(3 each)

17. Density and viscosity

18. Vectors and scalars

19. Velocity and acceleration

20. Distance and displacement

Give an example of a simple machine that:(3 each)

21. allows you to exert a smaller force over a greater distance.

22. lets you exert a large force in order to increase the distance an object moves.

23. whose primary purpose is to change the direction of motion.

y/description questions.

Explain why a wheel and axle is sometimes described as a ine related to a lever.(5)

What determines the "class" to which a lever belongs? How do functions of the various classes of levers differ?(5)

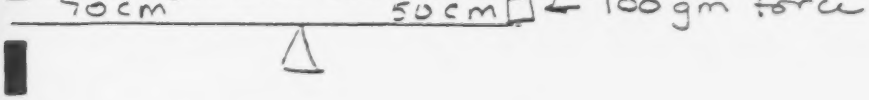
plete the table below (12)

ME	DEFINING FORMULA	FUNDAMENTAL UNITS	DERIVED OR RENAMED UNITS
XAMPLE: RCE)	mass x acceleration	(kg x m)/sec²) (a vector)	newton
eleration			none
locity			none
k			joule

Problems 3ea.

The distances that high school and college runner compete at different. A good high school female distance runner will run 0 meters in 5:05 (5 minutes, 5 seconds). A college runner runs 0 meters in 4:55. Who has the greater speed?

What weight will balance the seesaw below?



The diamter of the doorknob is 3 inches. The diameter of the is one inch. What is the mechanical advantage of the rknob, and what does that mean in terms of opening the door?

BEST COPY AVAILABLE

MATHEMATICS 310/PHYSICS 460

PRETEST

Note. These items were taken from an eighth grade textbook and represented items from all chapter of the book.

1. Round 8149.7356 to the hundredth place.

2. Write in expanded form using exponents. 45,936

3. Write in scientific notation. 376,000,000,000

4. Perform the operation and write your answer in simplest form.

   a. $4\frac{7}{12} + 9\frac{3}{8}$

   b. $12 \div \frac{3}{8}$

   c. Multiply 4 yd 11 in by 7. Write the answer in simplest form.

5. What is the name of the property illustrated?
   $(9.6 \times b) \times 4.1 = (b \times 9.6) \times 4.1$

6. Write the elapsed time between 10:35 a.m. and 2:50 p.m.

7. Write each in the form indicated.

   a. Write $\frac{5}{12}$ as a decimal.

   b. Write 0.124 as a fraction in lowest terms.

   c. Write the ratio as a fraction in lowest terms.
   45 minutes : 3 hours

   d. Write $\frac{30}{40}$ as a percent.

   e. Write 228% as a decimal.

8. Solve each problem.

   a. The gymnastics team needs 4 suits for new members. Some suits are on sale at 2 for $19.95 and other suits cost $10.95 each. How much money will be saved by buying the less expensive suits?

b. Daryl bought $1\frac{1}{4}$ lb of pecans, $4\frac{2}{3}$ lb of walnuts, and $6\frac{5}{6}$ lb of peanuts. About how many pounds of nuts did he buy?

c. Ms. Brown, the art teacher, had 3 c flour. She used $\frac{2}{3}$ c for papier mache, $\frac{3}{8}$ c for "clay," and $1\frac{5}{6}$ c as a paste to make all the supplies for 7 projects. How much flour did she have left?

d. In Frigid, Minnesota, the temperature was 5°C at 5 p.m. By 9 p.m. the temperature had dropped 7°. What was the temperature at 9 p.m.?

e. Tickets cost $7.50 each. A total of $262,500 was collected. How many people bought tickets?

f. What number is 120% of 619?

g. The sticker price for a 16 ft boat is $4325. Roger offers 8% below the sticker price. How much is Roger's offer?

Circle each number that is a divisor of 6048.

2 3 4 6 9

10. Use exponents to write the prime factorization of 560.

11. Perform each operation.

a. $|-42| - |25| =$

b. $336 \div -14 =$

12. Follow the directions.

Bev had only dimes. After using two, she had 40 cents. How many dimes did she begin with?

a. Circle the correct equation to use in solving the problem.

$10n = 40$ $40n - 10 = 20$ $10n - 20 = 40$

b. Solve the problem using the equation.

BEST COPY AVAILABLE

13. Solve each problem. Be sure to indicate a unit of measurement as well as a number.

a. Find the perimeter of a rectangle of length 29 m and width 16.4 m.

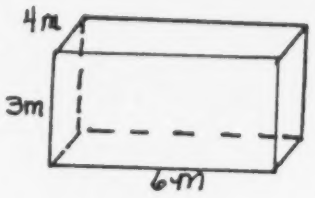
b. Find the circumference of a circle with radius 8.6 m. Use 3.14 as an approximation of pi and round answer to the nearest hundredth.

c. Find the area of a triangle with base 40.2 mm and height 37.4 mm. Round answer to the nearest hundredth.

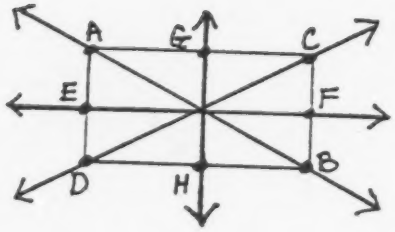
d. A circle with a radius of 4 m and a square with sides of 8 m are arranged so that a vertex of the square is at the center of the circle. What is the area common to the figures?

e. A tower casts a shadow of 9 m and a tree next to the tower casts a shadow of 0.6 m. If the tree is 1.2 m tall, how tall is the tower?

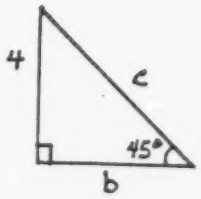
f. Find the surface area.



14. Name the lines of symmetry.



15. Solve for b and c.



16. Solve for d. $3\frac{3}{4} - d = 60$

17. Consider the set of data: (95, 99, 97, 98, 92, 96, 98, 96)
Find each of the following:

a. range

b. mean

c. median

d. mode

18. Only 4 runners race on a team. How many different ways can a team be formed from 10 runners?

19. A box has 2 purple pens, 2 red pens, 3 yellow pens, and 1 blue pen.

a. You pick a pen at random. Find the probability that it is purple or blue.

b. You pick a pen at random and do not return it. You pick a second pen. Find the probability that the first pen is red and the second pen is yellow.

20. A box contains 700 buttons. A random sample contains 4 white buttons, 3 gold buttons, and 1 black button. How many buttons in the box would you predict to be the given color?

a. white

b. not red

APPENDIX H

BEST COPY AVAILABLE

Student Information Form

Circle one or both: Math 310 Physics 460

Name _____ ID# _____
Major _____ Advisor _____
Class ____ Freshman ____ Sophomore ____ Junior Senior ____
High School _____

If you are an undergraduate student with a major in Early Childhood Education, Middle Grades Education, or Special Education and you are **not** registered for both Math 310 and Physics 460:

1. Explain why you are not registered for both classes this quarter.

2. In what quarter did you complete the other course?_____

Please indicate the number of years of each that you completed in high school (8 - 12):

_____ Mathematics
_____ Biology
_____ Geology or Earth Science
_____ Chemistry (year? _____)
_____ Physics (year? _____)

Give a descriptive name for each college math or science course you have completed, the year completed, and the institution. **Note**: If you are a graduate student in secondary math or science, write the name of your undergraduate major instead of listing courses.

Mathematics Course/Year/Institution	**Science** Course/Year/Institution

Make any comments that you consider appropriate concerning your mathematics/science background and/or interests.

Mathematics 310 and Physics 460
Opinion Survey

A. I am enrolled in:
(Circle One) Math 310 only Physics 460 only

Both Math 310 and Physics 460

B. Please describe briefly the advantages and disadvantages of enrolling in both Math 310 and 460 during the same quarter.

Advantages:

Disadvantages:

C. Please rate on a scale of 1 (not valuable) to 5 (very valuable) the small group cooperative activities in which you have engaged in class. Write comments if you wish.

1 2 3 4 5

Comments:

D. Please rate on a scale of 1 (not valuable) to 5 (very valuable) the field experience at Long Branch Elementary School. Write comments if you wish.

1 2 3 4 5

Comments:

. Consider the following limitations on the two courses:

1. These are content courses, not methods course.
2. We must work within the time limitations of the quarter system.
3. The instructors have limited control over placements, timing, and conditions in local schools.

aving considered the limitations, what constructive recommendations for change can you make o assist the instructors in the future?

Mathematics 310 and Physics 460
Opinion Survey - Sample Comments

A. I am enrolled in:

Math 310 only.....8
Physics 460 only.....0
Both Math 310 and Physics 460.....24

B. Please describe briefly the advantages and disadvantages of enrolling in both Math 310 and 460 during the same quarter.

Advantages:

Math 310 and Physics 460 students:

When we go out into our own classrooms (especially early grades), we will encounter those ingenious students who will inevitably want to know "what this has to do with anything?" (Math especially). With this combined class we are taught "links" between subjects which we can, in turn, teach our own students. Of course, for me personally it is a lot less busy work (or repetitive work, I should say) and much better in my time schedule to do one field experience.

An advantage of being enrolled in both classes is that the material is closely related and having both classes at the same time helps one to grasp the information more readily.

The two courses seemed to reinforce each other. Things learned in math helped us to understand science and also the opposite. The teachers working together helped to get tests separated which helped a great deal.

Both the courses worked together to provide the instructional material. The courses went well together. I like the hands-on approach to both the science and math classes. I felt this helped me better understand the material. Another advantage was that the week we went out into schools, the teaching unit used both math and science manipulatives. Another advantage of taking both at the same time is the scheduling. You knew Monday through Friday 1 - 3 you had class. You didn't have to try to work one or the other in. Another advantage is that both teachers worked together on the scheduling of resource files and tests. This helped a great deal.

One does get to see how math and science can be taught together to our students as well as to us.

One advantage is that a lot of the activities discussed in the classes can be applied together. Also since each class has a resource file to do, after you finish one, the other one may not require as much work because they are very similar as opposed to a totally different project.

Professors worked hard not to place heavy loads on students at same time. Tests, projects, homework were spaced well. Thanks.

The material is complementary to each course - ex. scientific notation, estimation. The field experience is only done once.

The field experience being combined into one week was excellent instead of teaching math one week then teaching science another. Incorporating both was an excellent idea.

Disadvantages:

Math 310 only students:

I felt that not being in both that I lost out on some information, especially for the field experience.

Math 310 and Physics 460 students:

The only adverse reactions I have heard and do completely understand is (as with everything at NGC) scheduling. Since this is a 10 hour "chunk" that must be taken together - it forces some people into 20 hr. quarters which they might not be able to handle - this problem can be solved if all advisors sit with you at the beginning of your trek to an education degree and plan every quarter (tentatively, of course) for all four years.

It can be overwhelming at times. The joint sessions were very confusing because of so many worksheets and differences. Also, it's not really fair to count the same grade for both classes in the teaching. If I got a harder teacher grading my lesson plans, then that grade could hurt my other class!

The only disadvantage is that taking these classes together will require a lot of work. I feel that the advisors should stress to the students to only take these two classes together with one other, not more than 15 hours at a time.

Material is so similar it's confusing sometimes / I'm not good at math or science - so it's very overwhelming and difficult for me.

Long class hours everyday. Going over material that should already be learned.

C. Please rate on a scale of 1 (not valuable) to 5 (very valuable) the small group cooperative activities in which you have engaged in class. Write comments if you wish.

	1	2	3	4	5
Math 310 Only Students	0	2	2	4	0
Math 310/Physics 460					
Math 310	0	2	4	10	9
Physics 460	1	1	6	8	8

Comments:

It helps to have people to ask questions to and get more than one opinion about problems.

The small group work could really be done individual. Basically that's what happens. One person ends up doing more work or everyone works on their own. In math this is especially true. If you have a person that really understands that person goes on. In science it's more of a cooperative deal even though sometimes a person tries to dominate the group.

The group work could be boring at times. Maybe not so much time should be allowed.

I very much appreciate the small group activities as it eliminates "listening to lecture" for 2 hrs. I believe that students not only need this variety for attention sake,but that it also provides students to witness how other students come up with different ideas and answers. I also believe that the small group work has drawn the class together as a whole rather than just being an individual in a math or science class. I've gained support from people as well. It'sm a i n l y been interesting to see how others think and then apply some of their ideas to your own. It's been a tremendous help. I've also been able to meet and become friends with people that I might not normally have pursued.

Group work is an excellent concept. However, the fact that people work on different levels at different speeds causes some people to bored when waiting for others to catch up. I do like the fact that we are getting to handle the things we'll be teaching with.

Math - in a group, you can work faster - possibly not be stumped on one concept for another student probably will know the answer. Science - It definately [sic] helps to have a "hands on" experience rather than learning the information from models in a book. Each student helps the other in a group situation.

D. Please rate on a scale of 1 (not valuable) to 5 (very valuable) the field experience at Long Branch Elementary School. Write comments if you wish.

	1	2	3	4	5
Math 310 Only	0	0	0	1	7
Math 310/Physics 460	0	3	2	6	13

Comments:

Math 310 Only

I felt it was a valuable experience, but it also had some problems. It was too short of a time to be very effective; or to see the student's true progress. By the time we became used to the students our time was up and our evaluation/lesson plans were due. An excellent idea for field experience but with some revision. Possibly a 2 week period out in the school to see a true learning experience. Give the weekend to write an adequate overall reflection, rather than a last day two minute one because of our class schedule at NGC. Overall, an excellent idea.

Math and science can be intimidating topics to teach. The preparation we did helped overcome some of the fear. In addition every field experience is a valuable learning experience for future teachers.

This was a great experience. It make me realize how important the teaching methods we learned were. It also gave me experience in this area.

Math 310/Physics 460

I did not really learn anything. It was just practice work. The lesson plans were not challenging because all I had to do was copy/rewrite what was given to me. The time of the day is awful - right after lunch and late spring quarter. The kids are ready to get out and only half listen.

The field experience was very helpful. I was very nervous being observed on the first day because it was my first field experience. Maybe observation could take place after the first day.

Instead of waiting 4 years to apply what I learned, I was able to apply new knowledge right away. It helped me understand NOW where I needed improvement and what I was comfortable with. In other words...it helped me find my strengths and weaknesses.

In my situation, having no prior experience with teaching, this opened the door. It really lets you get a true feeling of what is in store for you in the future as a teacher.

This time at Long Branch gave me the chance to work with the hands-on materials. I was

able to find out the best way to deal with materials and students at the same time. This was the first chance that I really got to try activities, like the ones we did, in a classroom setting.

It helps to be out in the schools and see what students can and can't do. I don't know if I would do the same activities, though. I felt I wasn't as prepared to teach the lesson as I should have been. Part of this was my fault, but I think the class could bave been better informed about our teaching experience.

It helped me see how science and math can be related and integrated together and taught in fun activities - and it made them seem easier to actually teach.

I think all the experiences in the actual classrooms in every class is very valuable. I liked having the classroom divided between 3 NGC students so that I only had to deal with eight 3rd graders. For me this was the first time I had ever done anything other than observe in the classroom. Although this was a good experience for me - I do think that the amount of teaching experience that the student has should be taken into consideration when evaluating performance.

It was hard going to a school not knowing what the children are like and the knowledge they already have. A lot of the concepts we had to teach were too difficult for the students.

E. Consider the following limitations on the two courses:

1. **These are content courses, not methods course.**
2. **We must work within the time limitations of the quarter system.**
3. **The instructors have limited control over placements, timing, and conditions in local schools.**

Having considered the limitations, what constructive recommendations for change can you make to assist the instructors in the future?

Math 310 only students:

Do not try to cover so much material at one time. It is not possible to do this and do it effectively. Since this is teaching us "how to" teach math in K-6 or 7 we need practical application and notquickly an overview of "how to." Some people may still feel uncomfortable with teaching math with an overview course. Otherwise, to do this much material in a quarter is possible but very crammed together. Good course - just too much for one quarter.

I believe it would be beneficial to spend less time on small group work and more time on other content areas. Small group is a valuable method of teaching and an occasional experience with it would be suitable to illustrate this approach.

The instuctors worked very well under the limitations and should be applauded for their great work.

As far as the limitations because of the local schools, maybe the instructors could talk with several local schools in order to find out which school would work best for a particular quarter.

Math 310 and Physics 460 students:

Allow the Fridays to be research days. Students may visit the schools, plan their lessons. Communicate during a set time for groups. Allow these days for students needing extra help and for total group work for the classes.

For the content part, I think it is handled well. The control of local schools cannot be changed but closer contact with teachers and what they want may help with further problems.

I think that method should be stressed more than it is. It is important to give the students more helpful pointers so they won't feel overwhelmed in the field. I realize this is hard to do because of all the levels that the students are on but it would be helpful and it might serve as a good review for the more experienced teachers.

We receive methods in block. Suggestion - either require block before these two classes or separate the methods class from block and require it before taking class. I think the teachers have worked out the time problem very effectively. I think the placement works out okay.

Since the time in the field classroom is so short, I would suggest something a little more informal from the lead teacher, such as a comment sheet because again there simply could not have been an accurate evaluation of anyone's performance based on one day. This would make everyone a little more comfortable to explore methods and not feel pressured to perform on command.

I think students should be given the opportunity to take them separately. I have 20 hours this quarter and these two classes were very difficult for me.

I feel that the field experience should be more organized. The teachers at the school seemed very displeased with the activities we were given to do. I think next year there should be different types of activities for the students to do.

Maybe a materials file could be added to aid those in finding resources. If the enrollment requirements are to enroll in both Physics 460 and Math 310, maybe the courses could combine and require one materials (file) covering both math and science. This would be an invaluable resource for beginning teachers.

Perhaps the focus should shift from content to method. The information taught should be review and if students don't know it, they need a Dev. Studies class. This material is elementary math and science. I need to know more on how to teach not what to teach. The school systems and texts given to me when I teach will tell me the "what." I will need alternatives to the "How."

That the field experience be discussed more and more of what to expect in classroom time. Some of us who had never had any teaching experience were lost and did not know how to handle situations such as discipline problems. This should be taken care of in the classroom instead of in the field.